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An Analysis of the Sheet-Metal Worker's Trade and a Curriculum for the Training of Teachers of Sheet-Metal Work in Industrial Arts Courses

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Foreword

This treatise consists of excerpts from a thesis, *An Analysis of the Sheet-Metal Worker's Trade and a Curriculum for the Training of Teachers of Sheet-Metal Work in Industrial Arts Courses*, which was submitted by the author in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Education, Indiana University, in 1931. The investigation was an attempt to do two specific things: (1) to make a complete analysis of the sheet-metal worker's trade; and (2) to use this analysis as the basis for the construction of a curriculum for the training of teachers of industrial arts in the field of sheet-metal work. As the analysis was merely a means to the second purpose above named, much of the material dealing therewith has been omitted from this abstract; however, before proceeding to the material incorporated in the abstract, the author feels that there should be presented brief statements of the contents of the chapters which are not included.

The second chapter of the thesis, "Early History of Metal," deals with the early history of the metals that have been used in sheet-metal products; condensed accounts of copper, brass, bronze, zinc, tin, and iron are given. The opinions of leading authorities upon the subject of trade analysis have been presented in the fourth chapter, "Trade Analysis." These give the meaning of trade analysis, the information that it should list, the things that must be taken into consideration by the analyst, and the problems for which he should search. There also have been presented reviews of many research studies in the field of occupational analysis. There has been established, it would seem, a strong case in behalf of such analyses for a variety of useful purposes. The fact that there is great need for skilled workers in the building trades is stressed in the fifth chapter, "Need for Trade Analysis in the Building Trade." The tables in the chapter show that the present system of apprenticeship is not adequate to meet the needs for trained workers and that the American building industry has depended largely upon foreign-born and foreign-trained workmen. Leaders of industry as well as educators are agreed that industrial workers should be given part of their

inspiration and instruction in the public secondary schools. When an industrial arts course in the secondary schools is based upon the work of some trade, an analysis of the trade is necessary to indicate the learning units to be taught. The types of activities placed in the industrial arts course may be influential in indicating the interests and aptitudes of pupils in relation to the problem of possible future trade training. Analysis of the sheet-metal worker's trade is given in the eighth chapter, "The Analysis." It was found that the work of the trade falls naturally into eleven divisions or units. The objectives, the type job specifications, type jobs, technical information, and auxiliary information are listed for each unit. The technical information includes the required trade mathematics, trade science, and trade drawing. The auxiliary information gives the trade terms, care and use of tools, safety precautions, and knowledge of stock.

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William Duschane of the Pentecost and Craft Company of Terre Haute assisted in making the analysis of the sheet-metal worker's trade. W. F. Rogers, president of the organization of sheet-metal workers of Terre Haute, and A. W. Dudley, president of the Master Sheet-Metal Association of Terre Haute, have checked the analysis. Especial recognition is due Doctor Melvin S. Lewis, Professor of Education, Indiana University, whose valuable encouragement, guidance, and assistance have been given freely throughout the progress of this study.

Introduction

The sheet-metal worker's trade is one of the important trades, not only in the building industry, but also in other lines of construction work. The present age is one of better and more comfortable homes, better shelter for animals, and better places to store food for both man and beast. In all this development sheet-metal has played an important part. This material is comparatively cheap, and with little care and paint is permanent.

The scarcity and high cost of lumber together with its fire and lightning hazard have led to the use of sheet-metal for roofing material, siding, outside trim, doors, window sash, and inside trim. This has opened up a large and new field for sheet-metal workers. An enormous amount of grain has been consumed every year by rodents because the places in which it has been stored did not afford proper protection against such marauders. Sheet-metal not only prevents such waste but is also a better protection against fire and lightning. In many cases on the modern farm, barns, silo, and other outbuildings are covered entirely with metal. Better homes, offices, and store buildings require modern heating and ventilating systems. All of these uses for sheet-metal involve a large amount of work and workers.

Formerly most of the metal work was done by hand and the services of a skilled workman were utilized. During this period a boy could become the apprentice of such a workman and thus learn the trade. At the present time a large number of plants manufacturing sheet-metal products have come into existence. They produce about seventy-five per cent of the materials that go into building construction and heating and ventilating systems. Practically all the metal ware used in the home is now stamped with dies in factories. This growth of factory manufacture has caused a decline in the apprentice system in sheet-metal work until now there is a shortage of skilled workmen. The United States census from 1870 to 1920 shows that during that period a large number of metal workers came to this country from other countries. After the passage of the immigration law of 1924, this supply of skilled

workers was diminished. Little has been done in recent years in this country to supply skilled metal workers through apprenticeship training. Any study of the labor supply for the sheet-metal worker's trade, therefore, will be of social value.

The Problem

What the problem is—The specific problem of this study is to make an analysis of the sheet-metal worker's trade which is to be used as the basis for a curriculum for the training of teachers of sheet-metal work. No attempt has been made to secure facts of particular use from the viewpoint of industrial vocational classes or schools, or from the point of view of industrial management, except as such facts appear as a result of the analysis specifically made. The work is mainly one of finding facts and classifying them. The task is to discover the working units of the sheet-metal worker's trade and then to arrange these units for instructional purposes in order of their difficulties. The attempt to train teachers of sheet-metal work for industrial arts classes in high and junior high schools has been hampered because of the lack of instructional material. An effort will be made in this study to find what particular applications of mathematics, of drawing, and of science are required in the sheet-metal worker's trade; also to ascertain other knowledge that the worker should have, such as terms used in the trade, care to be observed in using tools, precautions necessary for the safety of the worker, and the knowledge of the working properties and the size and gauge of materials used in the trade. After discovering the content of the trade by analysis, definite standards and objectives for each unit of the trade can be stated. The material is then arranged in instructional order and a method of measuring the student's progress must be established.

Limits of the problem.—This study must be limited to sheet-metal work that requires metal of ten gauge or lighter. Anything heavier than that is known as plate work; it requires dies to shape it and an acetylene torch and spelter to join it.

The curriculum for training teachers is limited to the training of teachers of prevocational subjects and related subjects for vocational classes.

Methods of Procedure

A study was made of source material and secondary material for the historical part of the thesis. The literature on job analysis was then studied to find the purpose and uses of occupational analysis. The material for this specific analysis was obtained by consulting directly men who are competent workers in the sheet-metal trade.

Sources of Data

For the phase of this study which deals with the early history and early and present uses of metals in sheet form the sources from which the data have been obtained are: ancient Greek and Roman literature; classical dictionaries of antiquity; the *Old Testament;* translations of Mau's *Pompeii,* Strabo's *Geography;* the *Pontificali;* records of Dr. Schliemann's and Mr. Mallowan's excavations; the books of Sir Austin Layard's travels; and Dr. Evans' archaeological work.

For the phases of the investigation which are concerned with trade analysis modern research literature on that subject has been utilized.

For the actual analysis of the occupation of the sheet-metal worker craftsmen of the trade were consulted.

The Sheet-Metal Trade

Early Uses of Sheet-Metal

That sheet-metal work was done in ancient times is evidenced by the relics found in prehistoric cities. Some of these metal relics plainly show that the ancient peoples had developed sheet-metal work to a very high degree of skill, although the tools used seem to have been few and simple. From *The Iliad*[1] and *The Odyssey*[2] and from the records of the excavations of Dr. Heinrich Schliemann[3] it is found that the only instruments used in the making of sheet-metal and sheet-metal products were the hammer, the tongs, and the anvil.

Several of the relics seem worthy of mention because of the sheet-metal used or because of the especial way in which it was employed. There is a large libation vase which was found in the Little Palace of Minow at Knossos. The vase is shaped like a bull's head, the head having been made of black stone inlaid with metal and the horns having been made of wood covered with gold foil. A fine natural touch was supplied by the long hair which falls about the head, the brow, and the cheeks of the animal. This was simulated by the use of incurved and angular patches inlaid with metal. Decorative features are small gold medallions with revolving rays set between the horns and the upper part of the forehead. These decorative features are clearly taken over from the metal technique and are like the revolving ornaments on the studs of a fine gold-plated sword found in the Knossian cemetery of Zafer Papoura.[4]

A very interesting example is a rosette formed from gold-plate, which was attached to the forehead of a silver bull's head taken from the Fourth Shaft grave at Mycenae. The ornament there appears in its true guise as a decorative adjunct to a masterpiece of delicately modeled and engraved metal work. This splendid piece of toreutic work, found in the Athens museum, has horns of gold-plate and gold inlay around the nozzle.[5]

The relics of the "Golden Age of Minoan Crete" indicate a great amount of rich metal ware. The Little Palace of Hagia Triada contained nineteen hundred bronze ingots, each of approximately the value of a light Babylonian talent. In the central mansion of the group at Tylissos was found a magnificient hoard, including, besides a bronze talent, four enormous bronze cauldrons; one of which is one and forty hundredths meters in diameter and weighs fifty-two kilograms. This cauldron was made of a round central dish, extended by a circular piece of three sections. Around the outer portion was a plain border of three segments. These plates were all riveted together by many rivets. The three handles were riveted to the cauldron.[6]

One of the best examples of a hoard of bronze objects at Knossos was found in the basement of a private house. That this hoard is of an exceptionally early date is shown by the rough painted pottery that was found with the bronze. Objects were found in perfect condition, coated with a bright green patina. One object of especial interest is a large cauldron, with expanding lips, three horizontally projecting handles, and a slightly rounded bottom resting on struts proceeding from the upper part of the legs. This cauldron is thirty-eight centimeters high and the upper diameter is also thirty-eight centimeters. In the basement of a neighboring house occurred another interesting bronze hoard. Here two very large tripod cauldrons were found; one of these was sixty centimeters high and sixty-one centimeters in diam-

[1]Homer, *The Iliad*, Translation by George Chapman (London: J. R. Smith, 1885), Book XVII, p. 447.

[2]Homer, *The Odyssey and Shorter Poems*, Translation by George Chapman (London: J. R. Smith, 1885), Book III, pp. 434-437.

[3]Heinrich Schliemann, *Mycenae* (New York City: Charles Scribners' Sons, 1878), "Preface," p. 25.

[4]Sir Arthur John Evans, "Tombs of Knossos," *Archaeologia*, Vol. LIX, p. 62.

[5]Sir Arthur John Evans, *The Palace of Minos at Knossos* (New York City: The Macmillan Company, 1851), Vol. II, pp. 527-533.

[6]*Ibid.*, pp. 627-628.

eter. With the cauldrons were a two-handled pan and a fine ewer with a second ringhandle below the other handle near its base.[7]

Good materials for historical study are afforded by a remarkable group of bronze utensils found in the "Tomb of the Tripod Hearth" at Isopatra. In this group there is a large bronze jug, the upper part of which is somewhat flat. Students of types and decorations say that this flattening and angular conformation of the shoulders shows a very ancient history on Cretan soil; this conclusion being drawn from the occurrence of the same features on a form of clay ewer of characteristic "mottled ware" found in an early deposit at Spoungaras of Early Minoan II[8] date. This vessel was clearly copied from a metal model, and even preserves a record of the studs of the rivets that fastened together its separate hammered-out plates. Thus it will be seen that this vessel retains characteristics that were executed by Minoan coppersmiths more than a thousand years before its date.[9]

In the "North-West Treasure House" at Knossos was discovered a group of vessels of truly palatial fabric. A magnificent basin is the largest of this group; it is thirty-nine centimeters in diameter. Its rim is hammered over outwards, the exterior margin being fashioned to represent the rounded end of leaves, and above this is attached, by means of soldering or welding, an upper rim with a beaded and foliated ornament chased in high relief. The handle of the basin is fastened on with four rivets. The wealth of metal vessels in this early palace was not of bronze alone, but also of silver and gold. In the case of the bronze types, the practice of coating them with a thin gold foil was also resorted to; at times a repousse plate of precious metal was attached to the rim. An example of this practice is also to be seen in a miniature silver bowl found in the Vapheio Tomb; the handle and border of the bowl are overlaid with gold-plate presenting a characteristic "whorl shell" motif.[10] A silver bowl from the Fifth Shaft Grave at Mycenae with a repousse gold handle and gold-plated rim affords another good instance.[11] This tomb also contained an ewer, made partly of silver and partly of bronze, plated with gold.[12]

Among the many interesting relics found in excavations at Mycenae were four boxes of copper filled with wood. The copper sheets were soldered together to form the boxes.[13] In a group of five copper vessels were three which showed that they had been used, for a long time, on fire. There was no solder used in the construction of these large vessels; they were solidly joined together with innummerable small pins. The handles were attached to the vessels by broad-headed copper nails. In these vessels were a large number of wooden buttons covered with gold.[14]

That the Mycenaeans used sheet-metal is further strengthened by the fact that five skulls were found covered by gold masks.[15] A large sheet of Mycenaen gold was sent to Doctor Price for analysis. Its weight was 1.702 grams and it was one one-hundredth of an inch in thickness.[16]

All the heroes of *The Iliad* are described as carrying a round shield large enough to cover the whole man.[17] Sarapedon's shield was forged of two sheets of bronze to which ox-hides were attached on the inside by golden bolts running around the circle.[18] Achilles' shield was made entirely of metal in five plates; two were of bronze, two of tin, and the central plate was of gold. The sheets were held together by a metal rim.[19]

The objects excavated from the prehistoric cities of Troy reveal that sheet-metal work was practiced very extensively. Molds

[7] *Ibid.*, pp. 630-632.

[8] The Early Minoan II Age is given as approximately from 2800 to 2200 B. C.

[9] Edith H. Hall, *Excavations in Eastern Crete, Spoungaras* (Philadelphia: Philadelphia University, 1912), Vol. III, p. 47.

[10] Sir Arthur John Evans, *op. cit.*, pp. 640-641.

[11] Heinrich Schliemann, *op. cit.*, pp. 319-320.

[12] *Ibid.*, pp. 316-317.

[13] *Ibid.*, p. 207.

[14] *Ibid.*, p. 215.

[15] *Ibid.*, pp. 219-222.

[16] *Ibid.*, p. 369.

[17] Homer, *The Iliad*, Translation by George Chapman (London: J. R. Smith, 1885), Book III, p. 347; Book V, p. 453.

[18] *Ibid.*, Book XII, pp. 294-298.

[19] *Ibid.*, Book XX, p. 270.

for casting metal were found; there were idols of lead. Diadems were cut with chisels from gold-plate; gold ware was soldered together for bracelets; and plates were bossed out and grooved, then soldered together to form earrings. Finger rings made from gold, were shaped on a bronze mandrel and then placed on charcoal and soldered.

The cups which were found in the third city are said to have been beaten out of a single plate of gold. The handles were made of a separate sheet which was formed into tubing and soldered together and then soldered to the cup. The alloy used as solder seems to be silver and gold and the flux was either borax or ground glass. "The Globular Bottle of Gold" was beaten out of a single plate of gold, twenty karats fine. The tools used were the hammer and tongs. Cups were also beaten out of single pieces of silver, and the handles were soldered on. Among other metal relics are spoons made of silver.[20]

Cups and vessels made of copper, bronze, silver, and gold were found in the other cities of Troy. Not only were there cups made of bronze or other metal, but there were also plated cups. Both gold and silver were plated on other bases. This discovery is important because here we first find baser metals coated with precious metals. This eventually led to coating corrosive metals with non-rusting metals.[21] In Strabo's *Geography* he speaks of some skillful man overlaying gold on silver. The Assyrians, also, finding that they could not give a pleasing appearance to objects made from iron, overlaid the iron with bronze.[22]

Among the ruins of Pompeii were numerous vessels and utensils of iron.[23] In a Pompeian kitchen was a bronze kitchen set. It consisted of cooking pots, ladles, dippers, pitchers, large spoons, table-spoons, pastry molds, two hundred pans, water heaters, and hanging lamps. These were made from sheet-metal.[24]

From its earliest days the Church is said to have employed utensils and vessels in its liturgical ceremonies. The history of the metal work of the Church in the Middle Ages, is, in fact, typical of the history of metal working in general in the Middle Ages. This is true not only because the Church was the foremost patron of such work, but also because almost all of the metal ware that has been preserved from the Middle Ages is ecclesiastical in character. In addition to this, until about the twelfth century the goldsmiths were almost exclusively clerics and monks.[25] The earliest explicit mention of the use of metal work in the Church dates from the third and fourth centuries. We find that Pope Urban had the sacred vessels made of silver and gold.[26] Besides the Eucharist cups there is mention of a great many gifts of vessels, statues, and images.

In the Cluny Museum at Paris are several examples of mediaevel use of various sheet-metals. Interesting among them is some devotional gold- and silver-work from the eleventh century. There are two crosses of chased and gilt bronze, which are examples of German art, one of the eleventh century and the other of the twelfth. Among the French art of the twelfth century is a Bible cover in openwork copper. There are rings of gold, of silver, and of bronze from the twelfth century.[27]

In a list of the household possessions of a well-to-do Norman peasant's family in the year 1345 are included: two metal pots, one metal bowl, two brass water jugs, a copper box, and a tin washtub.[28]

To give artistic form to shapeless masses of metal, three processes were used; namely, casting, chiseling, and hammering.

[20]Heinrich Schliemann, *Ilios, The City and Country of the Trojans* (New York City: Harper and Brothers, 1880), pp. 465-466.

[21]*Ibid.*, pp. 465-466.

[22]Sir Austin Henry Layard, *Discoveries Among the Ruins of Nineveh and Babylon, Second Expedition* (New York City: G. P. Putnam and Sons, 1853), p. 191.

[23]August Mau, *Pompeii, Its Art and Life*, Translation by Francis W. Kelsey (New York City: The Macmillan Company, 1902), p. 55.

[24]*Ibid.*, pp. 369-382.

[25]*Catholic Encylopedia* (New York City: D. Appleton and Company, 1907), Vol. X, p. 12.

[26]*Ibid.*, Vol. X, p. 14.

[27]Edmond Haraucourt, *Mediaeval Manners Illustrated at the Cluny Museum* (Paris, France: Librairie Larousse, no date), pp. 129, 167.

[28]Samuel B. Harding, *The Story of the Middle Ages* (Chicago: Scott, 1901), pp. 179-180.

Hammering was a very early method of shaping metal, and so far as giving artistic form to metals is concerned, hammering is the most important process. By the use of hammers the sheets of metal are hollowed out and thus become more pliable and plastic.[30] Hammering was one of the processes used by the coppersmiths of Dinant-sur-Meuse, who from the thirteenth century onwards, were so reputed for their wares that their name was given to numerous utensils which they manufactured from copper, bronze, or brass.[30]

The Byzantium cloisonne (partitioned) process of enameling is interesting in this connection, as the design is formed of thin strips of metal soldered edgewise to the face of the plate which serves as a base, the enamel paste being pressed and fused in the cells thus obtained.[31] Some of this work is found in the famous Pala d'Oro of St. Mark in Venice.[32]

The Utilitarian Trend

As men discovered ways of melting and refining metals, it became common for people to use many more metal products, and it became possible to reduce to sheets metals which were little used at first because of their hardness or because of their being found in an impure state. The more precious metals naturally were not used so much for utilitarian purposes, but the baser metals were utilized. Copper, however, one of the earliest metals to be hammered into sheet form, is still one of the most important metals used in the sheet-metal trade. This is partially true because copper is a good mixer; it enlarges its field of usefulness by alliances with other metals. Tin gives it the hardness of bronze; zinc gives it the golden glitter of brass; and aluminum unites with it to form new and useful alloys.[33]

Evidence of the sheet-metal craft and art, which was known to the Romans and introduced by them to England, has been found in excavations of Anglo-Saxon ruins belonging to the sixth, seventh, and eighth centuries. The material was employed for a variety of purposes, including fittings of wooden utensils, appliances for the protection of the person—as bosses of shields—and coatings of coins or other small objects.[33]

Further evidence of the early existence of the sheet-metal worker's craft in England is found in the records of workers' guilds. The first intimation of our present craft organization occurs in the reign of Edward IV, where it associated itself with the "Pinners" and kept its accounts in the same book. In the reign of Elizabeth it secured a charter. There are records of two trusts left to it in the seventeenth century; the proceeds of one were to be augmented by grants out of the company's funds and applied to pensions, and the other was to be used to erect almshouses.[34]

The sheet iron used by the earlier metal workers was made from wrought-iron heated in the blacksmith's forge and laboriously hammered flat and as thin as possible on the anvil. Then several sheets were heated together and again hammered until they reached the required thickness. These sheets necessarily were small. Next came the invention of the helve, a hammer operated by a water-wheel. This decreased the manual labor required and also increased the size of the sheet. These sheets were not coated but were in the form of black iron.[35]

The process of plating the sheets with tin was long a monopoly of Bohemia. In about 1620 it was introduced into Saxony.[36] In 1665 an English engineer was sent into Saxony to discover if possible the method of plating the iron. He was courteously received and was shown the whole process.

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[30]Beissel, "Verwendung edler Metalle Zum Schmueke römisher Kirchen Vom 5-9 Zahrh" in *Zeitschrift fur Christliche Kunst*, Vol. IX, p. 331.

[31]Edmond Haraucourt, *op. cit.*, p. 75.

[31]*Ibid.*, p. 118.

[32]Gino Fogolari, *The Gallaries of the Academy of Venice*, Translation by Rose Binetti (Milan, Italy: Fratelli Treves, no date), p. 2.

[33]Watson Davis, *The Story of Copper* (New York City: The Century Company, 1924), "Introduction," p. 11.

[34]W. Carew Hazlett, *The Livery Companies of the City of London* (London: Swan, Sonnerschein, and Company, 1892), pp. 646-647.

[35]J. M. Swank, *Iron in All Ages*, (Philadelphia: Allen Lane Scott, 1892), p. 47.

[36]Frank A. Weidman, *What is Sheet Steel* (Pittsburgh: Sheet Steel Extension Committee, 1927), p. 6.

After going back to England he and an associate undertook to manufacture it. They were successful in the process but had to give up making it because some jealous rival drummed up a patent. This rival lacked the technical skill to manufacture it and failed. Thus the manufacture of tin-plate died out in England and was not revived until almost one-half century later when John Hanbury started to make it. In 1728 he made the discovery of pressure rolls, which could do the work that had been done by the hammer. These rolls were at first driven by a water-wheel.[37] The cast-iron rolls did away with an immense amount of severe physical labor.

Much of the iron of England was of high quality. The charcoal iron of the English iron-masters of recent centuries is an example. This iron, however, was not ductile and easily worked like the sheet-metal of today. Sheet iron of that day was used for so few purposes, as compared with our own century, that these qualities were thought to be relatively unimportant. Iron was costly, hence durability was the first consideration. The reputation of English charcoal iron was built chiefly upon its ability to withstand many years of service. Atmospheric conditions, such as now result from clouds of coal smoke always present in industrial communities, were much less severe in former centuries when wood was the principal fuel. Yet there is no doubt that the skilled, if far slower, production methods of the English iron workers developed a sheet of an unusually high quality.[38]

The first tinware was introduced into the United States in Berlin, Connecticut, about the year 1740. At that time Edward Pattison, a recent colonist from Ireland and a tinsmith by trade, set up a shop for its manufacture on Hard Street in that town. This ware was a great curiosity at the time.[39] The tin used in the colonies was imported from England. The Revolutionary War stopped this importation of the tin plate from which the ware was made, but after the close of the war it was again imported. Others who had learned the trade from Pattison set up shops for themselves and the foundations of many fortunes were laid by peddling the ware in wagons through the West and South.[40]

The author of "Dwight's Travels" stated that after the War of 1812, ten thousand boxes of tinned plates were made into culinary vessels in the town of Berlin, Connecticut, in one year. He adds that peddlers went with the ware into every part of the United States.[41]

Modern Processes of Manufacturing Metal Sheets

All iron ore, as it comes from the mines, contains earthy matter and other impurities. The blast furnace is the first step in the actual conversion of the ore into iron and steel. This furnace does three important things: it separates the earthy matter and many of the other impurities from the ore; it releases the iron from the oxygen with which it is combined; and it adds the carbon which the soft iron requires to give it stiffness. In old-fashioned blast furnaces the molten iron was drawn off directly into sand molds or troughs, called "pigs." Hence the term "pig iron" is applied to the product of the blast furnace. Pigs permit convenient storage shipment of the iron. In modern practice much of the liquid iron is rushed from the blast furnace immediately to the iron mill for refining. Whether or not it ever becomes a a "pig," the product of the blast furnace is called "pig iron." It is the intermediate or semi-raw material from which practically all iron of whatever kind is made.

About 1847 an American, William Kelly, noticed that a draft of air striking molten iron made the metal seethe and boil. He remembered that the molten iron still contained carbon and other combustible material. He guessed that the oxygen of the air captured and carried away the excess carbon. In other words it boiled by burning its own fuel. This was the beginning of modern methods of refining pig iron and of making steel. A few years later an

[37] *Encylopedia Britannica*, Vol. X X, p. 478.
[38] *Sheet Iron, A Primer* published by Central Alloy Steel Corporation, pp. 9-10.
[39] *One Hundred Years of Progress* published by Peck, Stow and Wilcox Company, pp. 16-17.
[40] *Loc. cit.*
[41] Timothy Dwight, *Travels in New England* (Boston: Old South Association, 1823), Vol. IV, p. 468.

Englishman, Sir Henry Bessemer, stumbled on the same discovery. He reaped most of the fame from the discovery, hence the process is called the "Bessemer process." Air is forced by great pressure into molten pig iron. The air blast burns out or oxidizes a large portion of the impurities remaining in the pig iron. Most of the solid impurities, such as the oxides of manganese and silicon, rise to the surface of the metal as slag. There are also electrical processes of iron and steel making which have been in commercial use since the beginning of the twentieth century. The product of electrical furnaces is quite expensive, however, and is not used to a very great extent.

Soon after the discovery of the Bessemer process, a slower but more thorough method of refining iron was developed. This is caled the "open hearth" process. First limestone and then scrap iron are dumped into a highly heated basin; then a charge of pig iron follows. The heat is gradually increased to about 3,000 degrees Fahrenheit; this melts the charge of iron. The limestone, which has been burned to quicklime during the process, floats up through the molten metal and absorbs phosphorus, sulphur, and other impurities. They form slag on the surface of the purified iron. Small quantities of the metal are dipped out and tested, and when the chemical test is right and the temperature is proper for casting, the iron is allowed to flow out. It is carried by large cranes to rows of cast iron molds, where it cools and hardens into ingots.

The ingots are reheated for rolling. This is done with great care as the temperature from the center to the surface of each ingot must be uniform. Overheating causes surface defects after it is rolled. The red-hot ingot is then passed through a pair of heavy steel rolls; it can be passed either forward or backward through the rolls. As it passes forward and backward between the rolls, it becomes thoroughly worked on all sides and its width and thickness are reduced, while its length is increased.

The metal sheet is next introduced to the bar mill, which consists of a number of sets of rolls placed in a tandem arrangement. Here the sheet passes continuously from one set of rolls to the next and each bar decreases in thickness and increases in length as it passes through the successive sets of rolls. The final set of rolls gives the sheet the desired gauge or foot-weight. The sheet bar next travels on a table equipped with power driven rollers through a flying shear or saw, which automatically cuts the bar into thirty-foot lengths. The sheet is now ready to be taken to the sheet rolling mill.[42]

At the rolling mill the bars are cut into smaller sizes; the length of the sheet bar corresponds to the width of the finished sheet. For this reason it is introduced into the rolls at right angles to its length—that is, sidewise—and the rolling is continued in this direction until the desired length is reached. This is complicated by the fact that sheets twelve gauge and heavier are finished singly; thirteen gauge and lighter in twos; and still lighter gauge sheets in packs of threes, fours, sixes, eights—and rarely—sixteens. It is further complicated by the fact that sheets seventeen gauge and lighter must be reheated after being partly rolled out, because their cross sections are too thin to retain the heat long enough to complete the rolling. In all there are eight hot mill operations that all sheets must go through and eight additional ones that may or may not be required, depending upon the gauge and the kind or grade of sheet desired.[43]

The sheets as they leave the rolling mill are hard and stiff. They must be softened by annealing. This process also makes the sheets more ductile, removes strains that may have resulted from too rapid cooling, and improves the grain structure.[44] Blue, or open annealed sheets, are annealed, as the term implies, by being heated and cooled with no protection from the air. Because of the loose scale produced on their surface and the tendency of the sheets to warp in cooling, only heavier gauge sheets are annealed in this manner. Lighter gauge sheets are box annealed. They are piled on a bottom or stand and a heavy cast

[42] *Sheet Iron, A Primer* published by Central Alloy Steel Corporation, pp. 12-25.
[43] Frank A. Weidman, *op. cit.*, p. 7.
[44] *Sheet Iron, A Primer* published by Central Alloy Steel Corporation, p. 27.

steel cover is put over them. This is sealed around the bottom with sand to keep out the air. The box is then placed in an annealing furnace where the outside of the box is brought up to the annealing temperature and then allowed to soak in this heat.

The deoxidizing and bluing treatments are given the sheets as the box is cooling. The former is accomplished by introducing into the box a reducing or neutral gas which prevents the oxygen in the air from entering and forming scale or oxide on the sheets. The bluing is done by introducing steam into the box; in this way an excess of oxygen is supplied and blue oxide is built up on the surface of the sheets. Cold rolling is given to box annealed sheets before annealing, and to sheets to be galvanized, principally for the purpose of smoothing out the bends, curves, and kinks formed as a result of opening the pack after it comes from the hot mill. After a sheet has been annealed it is cold rolled again, if it is to have a smooth surface finish and polish.

The sheets are pickled by being immersed in a dilute solution of sulphuric acid which removes the scale formed during the rolling process. The sheet is pitted where this scale drops out. Subsequent cold rolling will heal the smaller pits, but those pits caused by bar scale are usually too deep. To insure against this condition, in the case of material requiring a perfect surface finish, the sheet bar itself, if it is light, is pickled. If it is heavy, it is partly rolled out and the "breakdowns," as they are called, are pickled. When sheets have been given this double pickling and have again been cold rolled, they are known as full-pickled, full-finished sheets.

The finishing treatments generally distort the sheets somewhat, and, as a final operation, they are levelled. Roller levelling will remove kinks and bends and correct some types of buckles, but if absolute flatness is required, the sheets must be stretcher levelled. In this operation the the sheets are held at both ends and pulled just beyond the elastic limit. The stretching results in the disappearance of all the buckles.

The forming operations are for the purpose of preparing sheets for roofing, ceiling, siding, metal lath, etc. Of these corrugating is the principal one, as it makes sheets suitable, by the added strength given them, for roofing, siding, culverts, flumes, and other purposes.[45]

It is apparent that a great variety of characteristics may be imparted to a sheet of steel by combinations and modifications of pickling, cold rolling, and annealing. The treatment of the sheet is determined entirely by the use to which it is to be put. The buyer should understand this and buy that which has been treated according to his needs.

Guarding against Corrosion

Sheets are coated against corrosion. Painted sheets are usually covered with an iron oxide paint which is applied by passing them through rolls saturated with the paint and then drying them quickly with heat.

Coating sheets with zinc, "galvanizing," is the means most extensively used to protect steel from corrosion. So long as zinc is in contact with iron, the iron will be protected, but this protection is at the expense of the zinc. This is due to the fact that anything that will attack both zinc and iron will first affect the zinc. Because of this tendency of zinc in contact with steel, the coating would soon disappear were it not for another peculiarity of zinc. When it is exposed to moisture, either as rain or moist air, it forms chemical compounds. These compounds are a mixture of zinc carbonate and zinc oxide, that are insoluble in water. This thin protective film is what dulls the sheet and detracts from its brightness and beauty. It cannot, however, withstand the erosive effects of wind and rain, but as it is worn down and washed away a new film replaces it. This continuous action gradually uses up all the zinc. In an atmosphere carrying acid fumes, the protective film is destroyed and the zinc corrodes rapidly. To insure long life for the coating, it should be painted as soon as possible after this film has roughened the surface sufficiently to permit the paint to adhere.

Sheets are galvanized by the hot-dipped method. They are first pickled to remove

[45]Frank A. Weidman, *op. cit.* pp. 7-10.

all scale, because zinc will not coat over any foreign substance on the sheet. They are then washed and placed for a few minutes in a dilute solution of muriatic acid. Next they are fed into rolls which guide them down into the sal-ammoniac flux; the flux thoroughly dries them and removes, by vaporizing, all traces of the acid solution. When it enters the molten zinc the sheet is thoroughly dry and clean. It is soon heated to the temperature of the pot and the zinc begins to alloy with the iron. As it comes up out of the bath the exit rolls help distribute the coating evenly over the surface and strip off some of the excess zinc that has adhered to it. Coating weights are controlled by the height of metal in the nip of the exit rolls, by the temperature of the bath, and by the speed at which the pot is run. Zinc will not satisfactorily coat a full-finished sheet, so such sheets are coated with a mixture of lead and tin."[46]

Copper, zinc, and lead are reduced to usable sheets in much the same way that iron is made into sheets. These metals, however, are never coated.

Men have long known that the admixture of two or more metals may serve useful purposes which neither alone could serve. One of the greatest triumphs of modern metallurgy came with the discovery of the value of copper as an alloying element to well-made iron and steel. It was found that copper, when alloyed in proper proportion, adds greatly to the rust and corrosion resistance of these metals. Research by commercial scientists about the beginning of the present century revealed the presence of small percentages of copper in many of the samples of early irons which had resisted corrosive action over exceptionally long periods of time. Their investigations led them to believe that the durability of much of the iron of centuries ago was due in some degree to the presence of copper. As the iron workers of ancient times were not able to reduce the iron to a liquid state, they could not have added copper to their iron. The copper, in varying percentages, must have been carried over from the ore. Many grades of iron ore today contain copper. Carried over into the finished iron in such slight percentages as .03 per cent it exerts some beneficial effect on the iron's corrosion-resisting properties. Maximum benefits are not derived, however, except when copper is alloyed with the molten iron in considerable proportions, usually from twenty per cent to fifty per cent. The resultant alloy has gone far toward cutting down enormous losses caused by rust and erosion. Spurred by the success attained through the use of copper, metallurgical science is constantly searching for new alloys which will make still further advances in retarding rust and corrosion. Shortly before the World War it was discovered that molybdenum as an alloying element checks still further the losses caused by the atmospheric destruction of iron. During the World War methods were developed for the successful use of molybdenum in the production of iron and steel. Molybdenum gives steel increased tensile strength. It imparts additional power to withstand shock and impact stresses. In the combination of copper and molybdenum with iron, it was found that the presence of a certain closely controlled proportion of copper was essential to the development of the maximum amount of corrosion resistance from the molybdenum content."[47]

Sheet-Metal Tools and Machines

The history of the manufacture of sheet-metal workers' tools and machines in the United States takes us as far back at least as 1785. Although the exact date of the beginning of the manufacture of these tools in our country is not definitely known, industrial history tells us that at that time one Elias Beckley was making tools in or near "Beckley Quarter," Berlin, Connecticut. One of Beckley's employees, Edmund North, and his brother, Jedidiah, taught the art of tool making to many who later went into business for themselves.

In 1806, Edward M. Converse, an inventor, began working on a folding machine for the manufacture of tinware. Thirteen years later his associate, Seth Peck, obtained in the patent office at Washington, a patent covering the new

[46] Frank A. Weidman, *op. cit.*, pp. 10-11.

[47] *Sheet Iron, A Primer* published by Central Alloy Steel Corporation, pp. 34-49.

machine—the first machine invented for making tinware. He started a little factory at Southington, Connecticut, and built a nation-wide business in a few years. In a list issued in 1826 of what constituted a full set of machines as manufactured by this factory there appear: folding, grooving, large turning, small turning, wiring, large burring, small burring, and setting-down machines. As manufacturers had no steam power until about 1850, the parts of the machines were turned by hand on lathes operated by the foot treadle.

About 1835 a Mr. Newton, of the Plant, Neal, and Company in Connecticut, designed the first double seamer ever made. It was known as "Newton's double seamer." The inventor was confident that the design could not be improved upon, but a year later a minister, Mr. Moore, designed a much better machine. The Moore double seamer, improved, is being manufactured at the present time. The first forming machine was introduced in 1845. These formers had two-and-one-half inch rolls.

William Bulkeley of Berlin, Connecticut, is credited with having made the first shears for cutting circles. He began making these shears in 1839; before that time circles were traced on the metal and were then cut to the line with a pair of straight hand snips. The Bulkeleys were the first to form snips and bench shears in dies. The dies consisted of a small block of steel bearing the impression of the snips or bench shears on the side opposite the cutting edge. Steel was heated to a white heat and placed in the die; the blade was formed by hammering the steel into the die by a hand hammer. This process gave the snips and bench shears practically as perfect lines on the outside as the present method of forming them in a drop forge. It is believed by many authorities that this invention was the first step toward the modern drop forge; the principle is the same.

The first squaring shears were constructed to operate by hand and were made by the Roys and Wilcox Company of Berlin, Connecticut. They were fastened to the bench and were operated by a hand lever in the manner by which photographs are trimmed at the present day. Hand power squaring shears continued in popularity until 1852; at that time patterns for the first foot treadle squaring shear were developed. A few years later a shear of more advanced design was completed. It was heavier, had a rotary lever motion, and was operated by a foot treadle. The operator, having both hands at liberty to manage the sheets, could cut more work with greater accuracy than formerly. The next improvement in squaring shears was in their capacity to cut longer lengths and heavier material, with a few improvements in gauges and minor parts.

In 1868 small sheet-metal machines were put on the market, which had the vital parts, as well as the gauged and small adjustments, encased. This was an important improvement. The number of machines has steadily grown and the tools have became more and more diversified until now there is a special tool or large power machine for almost every operation."

PRESENT IMPORTANCE OF THE TRADE

Compared to the limited field that they covered a few years ago, sheet-metal products are finding a broader application in the mechanical field. This growth is due to the combined results of miscellaneous development and of research carried on by manufacturers of sheet-metal products. Sheet-metal is now being used to make products that were formerly made from castings or forgings. This does not necessarily mean that castings and forgings are becoming undesirable, but that sheet-metal makers are finding new applications for their products. Competition has brought a continual change in design, tending toward reduction of labor and cost. Sheet-metal is today playing an important part in the automotive and aircraft industries, as well as in older branches of trade. Some of the newer products which are made of sheet-metal are stoves, cash registers, railway journal boxes, bath tubs, car seats, caskets, pulleys, gears, and brake drums.

In the building trades sheet-metal finds new uses, as it affords better protection from vermin and from fire and lightning. It is relatively cheap and after being paint-

"This history of tools and machines is adapted from *One Hundred Years of Progress* published by the Peck, Stow and Wilcox Company, pp. 1-19.

ed is very durable; hence its use is becoming practically universal. The ever-increasing cost of lumber and the relative cheapness of sheet-metal have led to the use of the latter in covering all types of buildings. In farm building the tendency is toward having all buildings covered with sheet-metal. In larger cities the buildings are trimmed entirely with sheet-metal; and the doors, window frames, and sashes are made of the same material. Sheet-metal work is an important phase of the building industry, as well as of other industries.

FACTORS OF EMPLOYMENT

Wages.—Corresponding, perhaps, to the different degrees of skill required in the numerous trades which contribute to the product of the builder, the average wage rates vary widely from occupation to occupation. In all occupations requiring any trade skill on the part of the worker, the present wage rates exceed one dollar per hour. The wages of the sheet-metal worker compare very favorably with those of workers in other branches of the building trades. The National Industrial Conference Board, through its research staff, has made investigations into wages, hours of work, and employment in American industries. In order to construct an average rate which would indicate with some degree of accuracy the trend of wage scales, a method of weighting was devised and applied to each of seventeen selected crafts in twenty-three typical cities. For each trade the rates prevailing in each locality have been assigned a weight proportional to the employment of the craft in the particular city and an average rate for the particular craft has thus been computed. In compiling the composite rate for the building industry as a whole, the average rate of each of these seventeen trades was again weighted by the relative employment in the total number of cities. The average wage rate for sheet-metal workers in 1927 was thus found to be 1.237 dollars per hour; while the average wage rate for the seventeen trades was found to be 1.151 dollars per hour.[49]

TABLE I

HOURLY WAGES OF BUILDING CONSTRUCTION WORKERS, DECEMBER, 1927[50]

Type of worker	Minimum cents	Average cents	Maximum cents
Bricklayers	132.5	155.0	175.0
Carpenters	70.0	124.7	150.0
Cement finishers	90.0	119.9	150.0
Electricians	81.3	135.5	162.5
Hod carriers	37.5	96.7	115.0
Hoisting engineers	75.0	127.1	171.9
Laborers	30.0	69.0	90.6
Marble setters	112.5	143.1	162.5
Painters	72.5	122.9	150.0
Plasterers	125.0	162.3	175.0
Plasterers' helpers	37.5	106.4	125.0
Plumbers	87.5	133.9	156.3
Sheet-metal workers	87.5	123.8	150.0
Steam fitters' helpers	37.5	80.5	100.0
Stone masons	112.5	151.3	175.0
Structural iron workers	100.0	144.2	175.0
Tile layers	100.0	140.1	162.5

Table I shows the average, the maximum, and the minimum rates per hour for these classes of workers in December, 1927, for the typical cities.

Table I shows that the wages of the sheet-metal worker compare favorably with those of other branches of the building trades. The study made by the National Industrial Conference Board also reveals that to secure a given amount of money earnings, the building worker has to labor

[49] *Wages in the United States, 1914-1927*, published by the National Industrial Conference Board, pp. 62-66.

[50] *Ibid.*, p. 67.

for a much shorter time than does the factory worker.[51]

Hours.—In all the cities from which data were received during this study, eight hours was the maximum number of working hours per day. The forty-four hour week was prevalent, the workers taking a half holiday on Saturday afternoon without pay.

Working conditions.—Sheet-metal work is carried on in the open as well as under shelter. Much of the inside work, however, is done before the buildings have been entirely closed; this leaves the workman exposed to the current temperature conditions. There is nothing injurious to the health of the worker in handling sheet-metal. This and the fact that much work is done outside contribute to the good health of the worker. During the months of December, January, and February the work is often limited to furnace and other repair work. Sheet-metal work affords many problems that make a strong appeal to pride in craftsmanship.

Trade organization.—The sheet-metal industry is well organized. There are local and national organizations of both sheet-metal workers and sheet-metal contractors. The latter association has a Vocation Education Committee among other forward-looking committees. This committee has prepared a course of instruction for a systematized plan for teaching apprentices and is cooperating with vocational schools. In the various cities the sheet-metal workers are affiliated with the Central Labor Union.

Trade hazards.—The trade is not classified as very dangerous by insurance companies and is given a medium rating by accident insurance companies. The greatest danger is from working on scaffolds; a large portion of the accidents that occur can be traced to faulty scaffolding. The hazard here may be controlled by the worker. Since the scaffold is only a temporary structure, there is a temptation to economize in the amount and kind of material used in its construction. Special attention to material, to proper construction, and to proper bracing will insure against most accidents. There may also be injuries from metal cuts, from acid burns, and from heated soldering irons. These dangers also may be eliminated by care on the part of the worker.

[51] *Ibid.*, p. 69.

Entrance Requirements

The National Association of Sheet-Metal Contractors has stated the qualifications of a worker in the industry as follows:

> The sheet-metal industry calls for men of high intellectual and technical skill. It is impossible to make craftsmen out of weak and dull-minded material. Subnormal and backward boys are out of place in a sheet-metal shop. We believe the apprentice should be:
>
> First—At least sixteen years of age,
>
> Second—Have at least a grammar school education,
>
> Third—Be of normal physical soundness, and
>
> Fourth—Possess a reputation for honesty and ambition.[52]

Opportunities For Advancement

That a large percentage of the skilled workers in the trade are of foreign birth and training is shown in Chapter V, "Need for Trade Analysis in the Building Trade," which is omitted in this treatise. This supply has been greatly reduced by our recent immigration laws. The number of workers is diminished yearly by old age retirements and by death. This means that there is an opportunity for the well-trained workman. He may be advanced to the position of foreman or to that of layout man. Such a man may eventually be able to start in business for himself.

Summary

No attempt has been made in this section to give in detail the history of the uses of sheet-metal and the processes of its manufacture, but a brief sketch of each is included, such as may motivate individual research on the part of the student.

The historical sketch seems to have established the fact that sheet-metal was made and used by man in the early ages of known history. Some relics found in prehistoric cities have been described, because of the kind of metal used or because of the way in which it was employed. The trend toward using the baser metals for utilitarian products is mentioned and the

[52] *A National Apprenticeship Training Plan* published by the National Association of Sheet-Metal Contractors, p. 2.

earlier processes of melting, refining, and making metal into sheets are next described. Methods of guarding against corrosion are discussed and a history of the tools and machines used in the trade is included. The discussion of the present importance of the trade shows that sheet-metal is each year playing a more important part in the industrial world. The table of wages indicates that the wages of the sheet-metal worker compare very favorably with those of workers in other branches of the building trades. The trade is well organized, to the advantage of the worker; the trade hazards are comparatively small; the entrance requirements are not prohibitive; and one entering the trade will find favorable opportunities for advancement.

The information concerning sheet-metal as an industrial commodity and the status of workers in the sheet-metal field has been presented in this chapter to furnish the reader with a background to enable him to follow this investigation more intelligently.

How the Analysis Was Made

The first step in making this analysis was to secure aid of a highly skilled and intelligent sheet-metal worker, who was acquainted with all phases of the trade and who was willing to give his assistance to this investigation. William Duschane of the Pentecost and Craft Company, of Terre Haute, Indiana, consented to help with the work. Mr. Duschane served a full apprenticeship and had had about thirty-two years' experience as an apprentice and journeyman. He was and is considered one of the best men in the trade. So far as training and experience are concerned, he was well qualified to give authoritative answers to the questions asked by the analyst, who also had had training and experience in the craft. The study extended over a period of about one and one-half years. The question and answer method was used until Mr. Duschane became sufficiently familiar with the analysis to give the needed information. After the information was charted by the analyst, it was again checked by Mr. Duschane and then submitted to the president of the Master Sheet-Metal Workers and to the president of the Sheet-Metal Worker's Union to be checked and rechecked as to its accuracy and completeness.

A statement of the method used in making the analysis follows.

Listing the Jobs[53]

In analyzing the sheet-metal worker's trade, as it is found in the charts, a list was made of all the various types of jobs that a sheet-metal worker would have to do in order to become a skilled workman.

Dividing the Trade into Units

After listing all jobs, it became evident that certain groups of jobs called for the same kinds of skills, knowledge, tools, and materials. These were called *units* or *blocks*. It was found that a group of jobs dealing with hanging guttering required a certain kind of skill, knowledge, tools, and materials; hence this group of jobs was called the unit on hanging guttering.

Another group was found that required sheet-metal in an entirely different form, different methods of fastening, and some new tools. It also required new skills and knowledge. As the sheet-metal used in this phase of the trade was in each case some kind of roofing, this was called the unit on roofing.

In like manner, a group of jobs was found which called for developing patterns, transferring patterns to metal, cutting breaking, forming, and seaming or joining metals. This group of jobs, based on the kind of knowledge required, the kind of work done, and the place where it is done, is called the unit on shop work.

One group of jobs was found to require the use of outside covering and called for special skills, knowledge, and tools. This group was called outside trim. A related group required plain metal work, used on the inside of a building. This unit was called inside trim. Similar jobs were found requiring metals in artistic designs, which were usually stamped in patterns.

[53]The division headed "Listing the Jobs" was adapted from Chapter III of *Analysis of the Plasterer's Trade for Instructional Purposes* by Melvin S. Lewis.

They require greater skill in placing. This unit was called artistic inside trim.

A group of outside jobs required that special patterns, molding, and miters be used to finish buildings. This group of jobs necessitated special knowledge of materials and methods of fastening. The unit was called cornice work.

One group of jobs required special knowledge of atmospheric conditions and special types of construction. This was called hot-air furnace work. A group of jobs similar to this group in the kind of work but different in purpose was called ventilating, exhaust, and blower piping.

There was another group of jobs found to require special skills and knowledge of construction and fastening. This was called skylight work.

Each of these units is a definite part of the sheet-metal worker's trade. Not all workmen are able to do work in all units. The better craftsmen, however, are able to do all the jobs in exhaust, blower pipe, and skylight work. A few men are trained in the work of estimating. Some never progress beyond the work of the first two units. Regardless of the variation in men's ability in the trade, the trade includes all the skills and information listed in each of the units of the charts.

Instructional Order

Determining the progressional factors for a unit.—The units had been determined, the jobs had been listed under each unit, and the required information for each job had been ascertained; but they were not arranged in proper order for instructional purposes. A unit was then taken and all the jobs examined. It became evident that there were certain factors which affected the ease of learning, or which retarded the learner. For example, in the unit of skylight work it was found that some jobs required greater skill than others. The skill demanded might retard the learner and was a factor taken into consideration in all skylight work. When training a new man in the unit of skylight building, the job requiring the least skill would be given first.

It was also found that some jobs required a great number of operations. This might confuse the learner. Other jobs required only a few operations. Naturally, the job which required the fewest operations, if not more difficult, would be given first. Some jobs required more accuracy than others. Because of this, the job requiring the least degree of accuracy would be given first.

These factors and others which determine the ease with which the learner progresses, or the factors which tend to retard the learner, are called progression factors. These progression factors were taken into consideration in working out a learning order of the jobs in the unit. Usually three progression factors are considered sufficient for one unit.

Establishing checking levels.—After having determined the progression factors that affect the individual who is learning any unit of a trade, such as the unit of skylight building, there still is no check on a learner's progress. Only the starting point of the learner and the goal for trained workmen in this unit are known. There is still no definite means of checking the learner to see if the right progress is being made as he receives instruction in the various tasks of the trade. It then becomes evident that a scale for measuring progress at any point in the unit must be established. These stages in the unit which indicate the learner's progress are called checking levels. The number of checking levels required for any unit is a matter of judgment.

Determining type job specifications.—In the unit of skylight building, it was thought that four checking levels were sufficient by which to check the progress of the learner through the twenty-four types of jobs in that unit. A measuring scale, divided into four parts, was made for this unit. It was then necessary to determine what kind of typical jobs the learner could do at each checking level.

First the characteristics of the most difficult type of jobs that could be done by a completely skilled workman were specified. This description of the job naturally became the last checking level, or in this case number four. A description of the types of jobs that a learner, half trained, might be expected to do was placed in checking level number two; while the description of the type of jobs to be taught

a learner, just beginning to work, was put in checking level number one. These specifications for a group of jobs, which have the same characteristics in common and offer about the same difficulty but vary in degree at each checking level, were called type job specifications.

Determining the objectives.—As an example, when the unit on skylight building was studied, the question arose: "Since the object is not just to teach a series of jobs, but to train a man to be a sheet-metal worker, what is the object of the skylight building unit?" A detailed statement in regard to the learner in terms of what he can do and a description of what he knows when trained as a trained skylight builder was then written. For each unit a corresponding objective, in terms of the learner, was written. A statement of what a learner can do and what he knows at the end of any unit is called the unit objective.

Intermediate or checking level objectives.—The type job specifications gave a description of a group of jobs at each checking level. It was also considered necessary for the teacher to have a description of the man at each checking level. Statements of what a man can do and what he knows were then written for each checking level. Such statements were called checking level or intermediate objectives.

Arranging the jobs in instructional order.—After determining the progression factors, the checking levels, the type job specifications, and objectives for each unit, there were obtained a measuring scale and a statement of objectives; but the jobs in each unit were still not arranged for instruction. As the jobs in the unit must be taught in instructional order and not in production order, the scale was applied to the list of jobs that belong in that unit.

It was found that the simplest way to apply this learning scale to all jobs in a unit was to take one job from a unit; to consider the progression factors for this unit; and to examine the type job specifications for the different checking levels. The job was then placed in the level to which it was found to correspond most closely. This process was continued until all jobs were distributed into the various checking levels. In some cases the distribution required some shifting of jobs from one level to another before they were arranged satisfactorily. Jobs placed in various units were only typical jobs, not specific jobs, and were called type jobs. Now if the instructor would wish to teach these jobs, he simply would need to choose a specific job which corresponds exactly to the type job.

Determining the Required Information

The card list now contained the jobs the sheet-metal worker must do and the knowledge he must have in order to do each job well. It was found that there were many production jobs which could not be done properly without the use of mathematics, drawing, science, and a knowledge of the names of tools, materials, etc. The applications of mathematics, science, and drawing constitute the technical information of the trade; the names of tools and materials, safety precautions, etc., are classified in trade analysis as auxiliary information.

Determining the technical information.—Under the heading of technical information were included trade mathematics, drawing, and science. Under trade mathematics were listed measurements involving any special rules and calculations a sheet-metal worker must be able to make if he is a skilled workman. Under trade drawing were listed such types of drawing as design, development, and blue print reading. These types of drawing are essential to enable a workman to become highly skillful in sheet-metal work. Under trade science were included certain specific scientific facts. These were such as the effect of climatic conditions on sheet-metals, the effects of prevailing winds, the effects of fluxes on metals, etc. These scientific facts should be known to the skilled worker or his tasks cannot be satisfactorily performed.

Determining auxiliary information.—It was found that besides the technical information there was other information that a sheet-metal worker should have. This additional information consisted of such material as a list of trade terms, special points on the care and use of tools, the care and use of the materials being used, safety precautions for the workman

and his fellow-workmen, and a knowledge of stock, including kinds of material that may be used, the gauge, weight, and size of sheets, and the working properties of different metals. This kind of knowledge was called auxiliary information.

In looking over the technical information for all jobs belonging to a given checking level, it was found to be possible to sum up the special knowledge for the whole checking level. In a number of cases the information was so nearly the same that one statement was sufficient for the group.

Summary

The content of this section has dealt with the way in which this analysis of the sheet-metal worker's trade was made. The work of the analysis, it has been shown, was performed in the following order: the listing of jobs; their organization into units; and the arrangement of the jobs in the proper learning order, (1) by determining checking levels with their type job specifications and objectives, and (2) by placing the jobs into their proper levels and then determining minimum knowledge required to do the type of work included in each checking level.

How the Analysis May Be Used

Teacher Training

An analysis of a trade is fundamental. It furnishes the skeleton from which training courses may be developed to meet special conditions. This analysis of the sheet-metal worker's trade was intended, primarily, to meet the need of basic instructional material for the training of teachers of sheet-metal work in the public schools of the state of Indiana. The teaching of industrial arts is compulsory in the grades in all city and town schools in Indiana,[54] and the industrial art subjects are offered in many of the junior and senior high schools. This creates a demand for industrial arts teachers which the teacher training institutions must meet. The courses for these special teachers must meet the standard requirements established by the State Board of Education. As these specify an all-round training as well as specialized training, the teachers of industrial arts subjects are required to meet the same professional requirements that teachers of academic subjects must meet. Teachers of industrial arts in the grades and in the junior high school must have completed a two-year industrial arts course and the teachers of these subjects in the senior high school must have completed a four-year industrial arts course.[55] This analysis will afford a basis for instructional material for the sheet-metal work in such teacher training courses.

The teachers of industrial arts in the elementary school, in the junior high school, and in the senior high school are more and more making use of general shop courses, while the single-industry type of course is still utilized. This specific analysis will furnish a basis of content for sheet-metal courses of either the general shop or single-subject type.

Vocational Training

This analysis of the sheet-metal worker's trade has been made to conform to the standards of the Indiana vocational law, approved by the Federal Board of Vocational Education. This law provides for the establishment and maintenance of the following types of schools, all of which are of less than college grade.

Trade preparatory.—The objective of a trade preparatory course is to prepare for advantageous entrance into trade or industrial pursuits. Of these schools, the day trade school is organized for boys fourteen years of age or over, who have definitely decided upon a choice of occupation and wish to receive training in school in order to enter the trade for which the course prepares. The general industrial school is similar in objective and organization to the day trade school, slight modifications as to time schedule being permitted with reference to cities under twenty-five thousand population. Under the high school cooperative plan one group of students attends school a week,

[54] Indiana Vocational Law, Section 5.
[55] *Laws of Indiana Relating to Public Schools* (1927), p. 45.

or a certain period of time, while another group is employed at work in local industries or trades. At the end of the period of time the group which was in school the previous period goes to work on the same jobs held by the group which was at work the period before. This latter group then comes into the school to receive instruction.

Trade extension.—The objective of a trade extension course is to give a type of instruction to persons who are already employed in a trade or industrial pursuit which will supplement their daily work in order to enable them to become more proficient in the work in which they are engaged or to prepare them for advancement in the same general line of work. This type of training is offered in the evening school,—open to workers sixteen years of age or over, in the part-time classes which workers over the age of fourteen attend from four to eight hours a week at least nine months of the year, and in the intensive part-time course which gives trade instruction in short, intensive units during the dull season of the worker.

General continuation.—General continuation courses have as their primary objective the promotion of civic or vocational intelligence of young workers, the instruction being adapted to persons from fourteen to eighteen years of age. This instruction is offered in the part-time schools. Although this type of training is usually not considered directly vocational, vocational information and prevocational training are customarily given in order to assist in guiding young workers through the temporary positions which they hold to a more permanent type of employment for which they may show some potential ability.[56]

Teachers in all these types of vocational schools may find this analysis helpful in their sheet-metal courses. In the day trade school it may be used as a basis for training in manipulative processes, as well as for determining the content of technical courses. Although the workers who are students in the extension types of schools do not ordinarily desire training in manipulative processes[57] since they are engaged in that work in the shop, they are vitally interested in the technical side of the trade. The analysis will be helpful in determining the technical and auxiliary information to be offered, and in checking the student's progress in manipulative processes in the shops. As the analysis permits the units to be broken into short unit courses it is especially well-adapted to being used as a basis for instructional material in the intensive part-time course.

Cooperative Courses in Higher Institutions

Several of the higher institutions of learning have adopted "cooperative" courses in their industrial work. The University of Cincinnati is the pioneer in part-time cooperative education. For this reason this type of organization is sometimes known as the Cincinnati plan. The plan is the same as that used in the high school cooperative course. The term cooperative is here used in its narrow sense as meaning: "Half-time work and half-time school with an alternating shift and with cooperation between employer and school in the organization of school instruction based upon shop needs and in the organization of a definite plan of progression in the shop, usually under school supervision."[58] For a course in sheet-metal work offered by such a school, an analysis of the trade would serve as a basis for cooperation in the organization of school instruction and the plan of progression in the shop.

In Industry

The analysis of the sheet-metal worker's trade may be used in industry by the employment office, by the foreman, by the worker, and by the supervisor of apprentices. In the employment department it may be used: (1) To furnish information, so that officials in the office will be familiar with the jobs of the concern and be able to explain to applicants the de-

[56] *Trade and Industrial Education*, Federal Board for Vocational Education, Bulletin No. 17, pp. 24-28.

[57] *Ibid.*, p. 27.

[58] *Apprentice Education*, Federal Board for Vocational Education, Bulletin No. 87 of Trade and Industrial Series No. 25, pp. 192-196.

tails relating to the position applied for. (2) To determine the physical, mental, and educational qualifications necessary for successful performance of any type of work. (3) To indicate the previous training and experience desirable for any job. (4) To assist in determining the time required to learn a job. (5) To zone jobs in terms of the complexity of duties and value of the workers to the concern, thereby assisting in the development of a logical system of rating, promoting, transferring, and paying employees. (6) To reduce labor turnover. (7) To indicate the types of work for which training should be provided.

It will be helpful to the foreman: (1) To show the character of the job and the qualifications necessary to fill it successfully. (2) To standardize relations with the employment department. (3) To promote the study of each job and thereby facilitate the possibility of improvement. (4) To enable the coordination to be made of one type of work with another.

The analysis will be helpful to the worker for the following purposes: (1) To enable the applicant to know the conditions under which he will be hired. (2) To define the limits of work and duties. (3) To indicate the normal lines of promotion.[59]

Those companies which train apprentices have found that analyses of their work are quite helpful. We quote from E. W. Kempton, educational director of the American Steel and Wire Company. "Almost everyone who has employed or interviewed prospective apprentices has had experience with the young man who is willing to take a considerable reduction in his earnings, in order to transfer to a training course, provided he has confidence in the training plan and believes that he will be taught what he wants to know. In a certain company difficulty had been experienced over a period of years in the retention of apprentices. In fact, the executive had lost faith in the boys of today and had concluded that there was little use in attempting to continue apprentice training. He felt that the lack of success was all due to the rate of pay. The apprentice rates, however, compared favorably with those of other companies; yet the boys would not remain more than a year or two. After the situation was intelligently analyzed and a definite plan of supervised training installed, the situation changed. No difficulty is now experienced, as the boys recognize that they are getting what they want. The trouble was that there was no plan of training, no means for checking the foreman, and no attempt to ascertain whether or not the young man was actually being taught the machinist's trade or being retained as an operator.[60]

Summary

This analysis of the sheet-metal worker's trade may be used as a basis of training teachers of industrial arts in the manipulative processes of the sheet-metal trade and in determining the content of the technical courses. It will serve as a basis for instructional material in the industrial arts classes in the public schools and in vocational schools. In the part-time school it will furnish a system of checking the student's progress in the work of the trade. It will provide an effective instructional order for students in the classes of cooperative schools and will serve in this type of school as a basis for cooperation between school and employer. In industry the analysis may be of value to the officials in the employment office, to the foreman, to the worker, and to the supervisor of apprentices.

[59]Adapted from a list of uses given by E. K. Strong in *Job Analysis and the Curriculum* (Baltimore: Williams and Wilkins, 1923), p. 24.

[60]E. W. Kempton, *Keeping the Apprentice through the Period of Training*, Production Executives' Series, No. 69, American Mangement Association, pp. 6-7.

A Sheet-Metal Curriculum

Note: In this summary of the dissertation, there has been omitted the eighth chapter, "The Analysis," which is the actual analysis of the sheet-metal worker's trade. The analysis was made to enable the author to construct the curricula which are outlined in the following pages.

Curriculum Construction

Basis of organization.—In education it has become possible to apply some of the technique and many of the methods that have been responsible for the advance that has been made in the field of exact science. Scientific methods of collecting, recording, and evaluating the content of curricula are now being widely used. Although the scientific development of curricula was comparatively unknown two decades ago, it is now possible to determine in this manner both the content and the methods to be used in a course of instruction. A survey of actual life conditions can be made in order to determine the subjects to be taught and the relative amount of time to be allotted to each. Finally, after the aim of the course of study has been formulated and the subject matter has been determined, the latter can be arranged in proper instructional order. Thus scientific methods replace unsystematized opinion in fixing the outline and content of a vocational curriculum.[61]

There is a tendency to accept collective opinion in place of individual opinion when a revision of courses is considered.[62] The National Society for the Study of Education appointed a committee in 1924 to consider the subject of curriculum making. The twelve members of this committee pooled their ideas and from them formulated conclusions relative to modern methods of curriculum construction.[63]

In the process of curriculum making, it is necessary that a teacher have at hand at any stage of his teaching an outline of the general attitudes, the finer appreciations, the important concepts and meanings, and the generalizations which he wishes to secure as part of the outcomes of his instruction. "That part of the curriculum should be planned in advance which includes: (1) a statement of objectives, (2) a sequence of experiences shown by analysis to be reasonably uniform in value in achieving the objectives, (3) subject matter found to be reasonably uniform as the best means of engaging in the experiences, and (4) statements of immediate outcomes or achievements to be derived from the experiences. That part of the curriculum which deals with supplementary experiences and materials which are to be used as local conditions suggest, should be planned partly in advance and should be made partly as new materials become available. That part of the curriculum which represents the daily life-situations and interests from which the immediate specific needs of students arise, should be—can only be—made from day to day ."[64]

Determining aims.—There are various opinions as to what should be the aim or aims in education. In determining the aims for a curriculum in printing, Mr. Strong, when working with a faculty committee, determined that the aim of teaching printing should be to prepare men: to earn a living, to assume duties of citizenship, and to enjoy life.[65] The Committee on Reorganization of Secondary Education presents the following principles which, in the judgment of the reviewing committee, should guide the reorganization of the curriculum—health, vocation, worthy home membership, civic education, worthy

[61]Edward K. Strong and Richard S. Uhrbrock, *Job Analysis and the Curriculum* (Baltmore: Williams and Wilkins, 1923), p. 68.

[62]W.W. Charters, "What Has Thus Far Been Accomplished and Is Now Available for the Readjustment of School Curricula," in *Proceedings of High School Conference*, November 21, 1898.

[63]National Society for the Study of Education, *26th Yearbook*, Part 2, pp. 1-8.

[64]Committee on Curriculum Making, National Society for the Study of Education, *26th Yearbook*, Part 2, pp. 19-20.

[65]Edward K. Strong and Richard S. Uhrbrock, *op. cit.*, p. 73.

use of leisure, ethical character, and fundamental processes.[66] Franklin Johnson, professor of education at Teachers College, Columbia University, gives the fundamental aims of secondary school education as follows: health, vocational training, and worthy use of leisure.[67] H. H. Foster, professor of education at Beloit College, states as the objectives of education: health, fundamental processes, worthy home membership, vocation, civic education, worthy use of leisure time, and ethical character.[68]

In studying the opinions of these men, we find that all agree that two of the broad general aims of education should be health and vocation. From the results of the specific analysis of this study, it seems clear that *vocation* must be the aim of this curriculum for the training of teachers of sheet-metal work. Health, civic service, and all the other broad aims of education may properly be left to other phases of the educational processes to which the individual is subjected. For those who are to make a living from teaching industrial arts in the public schools this curriculum in sheet-metal work has the express aim of training for a vocation.

Fundamentals

The method of teaching sheet-metal is gradually changing from the practice of teaching shop work without giving instruction in pattern drafting. Shop work and pattern drafting are now being correlated in many courses for the training of apprentices in order that they may become more intelligent and efficient workers.[69] Pupils in industrial arts classes are given job sheets from which to work. With the aid of the instruction sheets the student is required, in most cases, to construct objects by transferring patterns to the metal. He must then cut, form, and fasten the parts together. After he has become familiar with the construction processes, he is required to draft the same pattern that he has used or a similar one. This method of procedure was approved by most of the craftsmen interviewed during the course of this study.

Curriculum for Use in Teacher Training Institutions

Teachers of shop work in the industrial arts field do not teach this work for the specific purpose of fitting the pupil for gainful employment in any of the trades. The work here is exploratory, being given for guidance and general education. The teacher of shop work in this field does not need the same qualifications that are required for the teacher of vocational shop work, the purpose of which is to train pupils to enter specific gainful employments.

The facilities of the sheet-metal shops in most teacher training institutions are such that all phases of the work of the sheet-metal trade could not be carried on successfully. In most cases practical jobs could not be secured. For these reasons the time and expense required to train the student in all the units found in this analysis would be greater than the results would justify. The most important fundamental operations and processes of the work are found in units one and four of the analysis; hence these units, soldering and shop work, have been taken as the basis for the construction of a curriculum for the training of teachers of sheet-metal work in the industrial arts field.

The objectives of the units given in this specific curriculum were developed from the job specifications obtained from the analysis of the sheet-metal worker's trade. Daily lesson plans should be prepared by the instructor in these courses. The plans should be revised if in the light of actual teaching experience it seems advisable. Finally they should be put into permanent form, covering all the details of the courses included in the curriculum.

Soldering

Objectives—

To give the student ability to: tin soldering coppers properly; choose the right kind

[66] Commission on Reorganization of Secondary Education, "Cardinal Principles of Secondary Education," Department of Interior, Bureau of Education Bulletin No. 35, pp. 1-13.

[67] Franklin Johnson, *Administration and Supervision of the High School* (Boston: Ginn and Company, 1925), pp. 14-17.

[68] H. H. Foster, *High School Administration* (New York City: The Century Company, 1928), pp. 14-15.

[69] *A National Apprenticeship Training Plan* published by the National Association of Sheet-Metal Contractors, p. 5.

of solder and fluxes; solder pieces of metal together; and make well-soldered joints of various types.

To give the student a knowledge of: soldering coppers; the melting point of the different metals; the composition and fusing points of solders; uses of fluxes; and kinds of fluxes that may be used with different kinds of metals.

Jobs—

Tinning coppers
Choosing solders and fluxes
Soldering together pieces of:
- Bright tin
- Clean galvanized iron or steel
- Clean copper
- Zinc
- Zinc and copper
- Iron and copper
- Dirty copper
- Dirty zinc
- Black iron and aluminum

SHOP WORK

Objectives—

To give the student ability to: transfer patterns to metal; cut; notch; break; fold; form; assemble; seam; hem; crimp; bead; furr; turn; wire; double seam; peen; raise; groove; pitch; use right tools and machines; take proper care of tools and machines; make all necessary calculations; observe safety precautions; draft patterns; and read blue prints and specifications.

To give the student a knowledge of: parallel, radial, and conical development; triangulation; properties and uses of various metals, fluxes, and solders; and modern trade practices.

Jobs—

Constructing from patterns:
- Circular cooky cutter
- Short pipes of small diameter
- Irregular cooky cutters
- Metal cup
- Non-flaring bucket

Drafting patterns for various types of of cooky cutters
Constructing from patterns:
- Double seamed quart measure with raised lid
- Double seamed pail with raised lid

Drafting patterns for:
- Two quart pail with raised lid
- Double seamed measure with raised lid

Constructing from patterns:
- Cone
- Frustum of same cone
- Square pyramid
- Frustum of same pyramid
- Frustum of an irregular cone
- Frustum of an irregular square pyramid
- Frustum of an irregular hexagonal pyramid
- A tapering outlet for gutter

Getting dimensions from objects and drafting patterns for each of the above projects
Constructing from patterns:
- A funnel
- A rectangular pitched hood
- An octagonal cover
- A flaring pan
- Two-piece 90 degree elbow in round pipe
- Round conductor elbow
- Pipe and roof flange

Drafting patterns for preceding projects from given dimensions
Transferring from patterns to metal, cutting, forming, and soldering:
- T joints between pipes of the same diameters
- Y joints between pipes of the same diameters

Drafting patterns for preceding jobs, using same dimensions
Constructing from given patterns:
- Two square pipes of the same size intersecting at an angle of 40 degrees
- Two hexagonal pipes of the same size intersecting at an angle of 60 degrees
- Two octagonal pipes of the same size intersecting at an angle of 30 degrees

Obtaining dimensions of pipes from preceding jobs and drafting patterns for:
- Intersection of two square pipes at an angle of 45 degrees
- Intersection of two hexagonal pipes at an angle of 30 degrees

Constructing from given patterns:
- Intersection of two pipes of unequal diameter intersecting irregularly
- Intersection of hexagonal pipe with square pipe
- Intersection of square pipe with round

pipe intersecting obliquely
Intersection of hexagonal pipe with octagonal duct intersecting obliquely
From given dimensions drafting patterns for:
Irregular intersection of two pipes of unequal diameter
Intersection of a square duct with a round pipe
Oblique intersection of two octagonal ducts
Constructing from patterns:
Three-piece 90 degree elbow
Four-piece 90 degree elbow
Five-piece 90 degree elbow
Drafting patterns of pipes four inches in diameter for:
Three-piece 90 degree elbow
Four-piece 90 degree elbow
Five-piece 90 degree elbow
Constructing from patterns:
Eave trough miter
Molded face gutter miter
Ogee gutter miter
From given dimensions drafting patterns for:
Half-round eave trough miter
Molded face gutter miter
Ogee gutter miter
Transferring from patterns and constructing:
Simple mold return miter
Butt miter
Oblique return miter
Butt miter against a surface oblique in plane
Drafting patterns for:
Simple mold return miter
Butt miter
Oblique return miter
Butt miter against a surface oblique in plane
Miter between a gable and a horizontal molding
From given dimensions constructing:
Square hopper six inches at the larger opening and four inches at the smaller
Square hopper to fit a round pipe, the hopper to be six inches square at the top and fit into a five inch round pipe
Intersection of a four by six inch rectangular pipe and a round pipe three inches in diameter
Intersection of two flaring pipes
Intersection of an oblong pipe and a cone
Ash chute head
Developing patterns for the foregoing problems

Suggested Curriculum for Vocational Schools

Although the analysis of the sheet-metal worker's trade was made for the purpose of obtaining data to serve as a basis for the construction of a curriculum for the training of teachers of industrial arts courses, the analysis will also serve equally well as a base for the construction of vocational curricula in the field of sheet-metal work.

For vocational classes in sheet-metal work, such as are found in the all-day trade school, the part-time school, and the evening school, the material found in the analysis would enable one to construct various types of short-unit or longer vocational courses adapted to the needs of workers representing different stages of progress and proficiency in the work of the craft. All such types of vocational schools have access to practical work and have more adequate equipment than is found in the industrial arts department, and consequently need a more comprehensive curriculum. To meet these needs the following curriculum is suggested.

Soldering

Objectives—

To give the student ability to: tin soldering coppers properly; choose the right kind of solder and fluxes; solder pieces of metal together; and make well-soldered joints of various types.

To give the student a knowledge of: soldering coppers; the melting point of the different metals; the composition and fusing points of solders; uses of fluxes; and kinds of fluxes that may be used with different kinds of metals.

Jobs—

Tinning coppers
Choosing solders and fluxes
Soldering together pieces of:
Bright tin
Clean galvanized iron or steel
Clean copper

Zinc
Zinc and copper
Iron and copper
Dirty copper
Dirty zinc
Black iron and aluminum

GUTTERING

Objectives—

To give the student ability to: use hangers, soldering irons, snips, pliers, and hammers; assemble in a straight line and solder gutters; calculate the fall, and the amounts and costs of materials needed; and observe safety precautions.

To give the student a knowledge of: gravity; effects of temperature on metals; methods used in hanging guttering; required fall; working properties of the different kinds of metals; tools used; city ordinances; and underwriters' rules.

Jobs—

Assembling, soldering, and hanging a short gutter without a return miter
Assembling, soldering, putting on ends, cutting opening for leader, and hanging a long trough gutter with return miter
Assembling in a straight line, soldering, fastening ends, cutting opening for and soldering on spout for leader, and hanging a molded gutter without return miter
Hanging molded gutter with return miter

ROOFING

Objectives—

To give the student the ability to: use proper insulation; lay sheet-metal roofs of various kinds; make proper joints; use nails, cleats, and flashing hooks; make proper seams; and observe safety precautions.

To help the student gain a knowledge of: shrinkage and expansion of metals; working properties of metals; use and care of tools; modern trade practices; city ordinances; and requirements of insurance underwriters.

Jobs—

Laying corrugated roofing on:
  Shed roof
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying crimped roofing on:
  Shed roof
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying pressed standing seam roofing on:
  Lean-to roof
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying self-capping roll roofing on:
  Lean-to roof
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying double standing seam roll roofing on:
  Lean-to roof
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying metal shingles and tiles on:
  Gable roof
  Gambrel roof
  Hip and valley roof
Laying sheet-metal roofing and metal shingles on:
  Conical roofs
  Towers
Laying sheet-metal tiles and shingles on:
  Domes
  Lanterns

SHOP WORK

Objectives—

To give the student ability to: transfer patterns to metals; cut; notch; break; fold; form; assemble; seam; hem; crimp; bead; furr; turn; wire; double seam; peen; raise; groove; pitch; use right tools and machines; take proper care of tools and machines; make all necessary calculations; observe safety precautions; draft patterns; and read blue prints and specifications.

To give the student a knowledge of: parallel, radial, and conical development; triangulation; properties and uses of various metals, fluxes, and solders; and modern trade practices.

Jobs—

Constructing from patterns:
  Circular cooky cutter
  Short pipes of small diameter
  Irregular cooky cutters
  Metal cup

Non-flaring bucket
Drafting patterns for various types of cooky cutters
Constructing from patterns:
Double seamed quart measure with raised lid
Double seamed pail with raised lid
Drafting patterns for:
Two quart pail with raised lid
Double seamed measure with raised lid
Constructing from patterns:
Cone
Frustum of same cone
Square pyramid
Frustum of same pyramid
Frustum of an irregular cone
Frustum of an irregular square pyramid
Frustum of an irregular hexagonal pyramid
A tapering outlet for gutter
Obtaining dimensions from objects and drafting patterns for each of the above projects
Constructing from patterns:
A funnel
A rectangular pitched hood
An octagonal cover
A flaring pan
Two-piece 90 degree elbow in round pipe
Round conductor elbow
Pipe and roof flange
Drafting patterns for preceding projects from given dimensions
Transferring from patterns to metal, cutting, forming, and soldering:
T joints between pipes of the same diameters
Y joints between pipes of the same diameters
Drafting patterns for preceding jobs, using same dimensions
Constructing from given patterns:
Two square pipes of the same size intersecting at an angle of 40 degrees
Two octagonal pipes of the same size intersecting at an angle of 60 degrees
Two hexagonal pipes of the same size intersecting at an angle of 30 degrees
Obtaining dimensions of pipes from preceding jobs and drafting patterns for:
Intersection of two square pipes at an angle of 45 degrees
Intersection of two hexagonal pipes at an angle of 30 degrees
Constructing from given patterns:
Intersection of two pipes of unequal diameter intersecting irregularly
Intersection of hexagonal pipe with square pipe
Intersection of square pipe with round pipe intersecting obliquely
Intersection of hexagonal pipe with octagonal duct intersecting obliquely
From given dimensions drafting patterns for:
Irregular intersection of two pipes of unequal diameter
Intersection of a square duct with a round pipe
Oblique intersection of two octagonal ducts
Constructing from patterns:
Three-piece 90 degree elbow
Four-piece 90 degree elbow
Five-piece 90 degree elbow
Drafting patterns of pipes four inches in diameter for:
Three-piece 90 degree elbow
Four-piece 90 degree elbow
Five-piece 90 degree elbow
Constructing from patterns:
Eave trough miter
Molded face gutter miter
Ogee gutter miter
From given dimensions drafting patterns for:
Half-round eave trough miter
Molded face gutter miter
Ogee gutter miter
Transferring from patterns and constructing:
Simple mold return miter
Butt miter
Oblique return miter
Butt miter against a surface oblique in plane
Drafting patterns for:
Simple mold return miter
Butt miter
Oblique return miter
Butt miter against a surface oblique in plane
Miter between a gable and a horizontal molding
From given dimensions constructing:
Square hopper six inches at the larger

opening and four inches at the smaller
Square hopper to fit a round pipe, the hopper to be six inches square at the top and fit into a five inch round pipe
Intersection of a four by six inch rectangular pipe and a round pipe three inches in diameter
Intersection of two flaring pipes
Intersection of an oblong pipe and a cone
Ash chute head
Developing patterns for the foregoing projects

OUTSIDE FINISH

Objectives—

To give the student the ability to: select proper material; cover walls; put on casing; use proper insulation; make all necessary calculations; and observe safety precautions.

To give the student a knowledge of: properties of materials; methods of fastening; effect of climatic conditions and prevailing winds on metal; pattern development; and blue print reading.

Jobs—

Covering outside walls of house with metal siding
Putting on:
Metal window caps, casing, sash, and sills
Metal door caps, casing, and sills
Drafting patterns for the preceding jobs
From given patterns transferring, cutting, forming, and erecting:
Metal lintel over window
Cornice
From dimensions secured on the job drafting patterns for:
Lintel of window
Cornice of door
From given patterns forming and erecting a broken pediment with raked return on a window
Drafting patterns of the members of a broken pediment with raked return

PLAIN INSIDE FINISH

Objectives—

To give the student the ability to: use furring strips; put on plain siding; make all necessary calculations; and observe safety precautions.

To give the student a knowledge of: materials that may be used; kinds of tools needed; care of tools; method of lapping sheets; building codes; and rules of insurance underwriters.

Jobs—

Putting on:
Furring
Metal siding on inside walls
Plumbing and fastening a window frame
Putting on:
Window casing
Apron
Stool
Transferring from pattern, cutting, forming, assembling, and fastening parts of sash
Putting on metal base
Hanging:
Fire door
Metal window sash
Developing patterns for parts of window sash
Putting on plain metal ceiling (This material comes all ready to be put into place.)

ARTISTIC INSIDE FINISH

Objectives—

To give the student the ability to: measure for siding and ceiling; put on furring, wainscoting, dadoes, and chair rails; plumb door and window frames; and put on ceiling.

To give the student a knowledge of: the use of a field, field border, panel border, mold filler, and cornice members; and the reason for starting ceiling at center. (The artistic work, such as the ceiling, comes stamped from the factory and no drafting is required.)

Jobs—

Putting on furring, siding, wainscoting, dadoes, chair rails, and plugging in:
Modern stores
Office buildings
Cafes
Churches
Auditoriums
Plumbing door frames
Putting on casings
Hanging doors
Plumbing window frames
Putting on casings, stools, and aprons
Hanging metal sashes
Putting on bases
Drafting patterns for:
Door frame

Door casing
Window frame
Window casing
Aprons
Stools
Window sashes
Putting on a ceiling including:
Furring
Field
Field border
Panel border
Mold filler
Cornice members

Hot-Air Furnace Work

Objectives—

To give the student an understanding of the principles underlying hot-air furnaces and the installation of the same. This involves the ability to: set the casting; place cold-air duct opening; put on jacket, cut openings for hot-air ducts; transfer from patterns to metal, cut, form, assemble, rivet, and solder wall stacks and wall stack boots; place wall stacks and wall stack boots; fasten wall stacks by soldering strips of metal to them and nailing these to the studs; insulate and fasten pipes leading from furnace to wall stacks; make register boxes from patterns; and compute the volume of pipes and stacks and the velocity of air currents.

To give the student a knowledge of: gravity; the effect of heat on air; the volume of water absorbed by a cubic foot of air at different temperatures; modern trade practices; city building codes; insurance underwriters' rules; drafting patterns; and blue print reading.

Jobs—

Placing:
Pipes leading to wall stack boots
Wall stack boots
Wall stacks
Floor registers
Making various-shaped:
Wall stacks
Wall stack boots
From collected data drafting patterns for:
Wall stacks
Wall stack boots
Placing floor register boxes
Hanging connecting pipes
Insulating:
Connecting pipes
Floor register boxes
From given patterns making floor register boxes
From given data drafting patterns for floor register boxes
Setting castings for furnace
Putting on:
Jacket
Hood
Cutting openings for connecting pipes

Ventilation, Exhaust, and Blower Piping

Objectives—

To acquaint the student with the principles underlying ventilation, exhaust, and blower pipe work and the operations involved therein. This includes the ability to: design, cut, form, and assemble air check valves, air filters, windbreaks, intake and exhaust ducts, elbows, pipe reducers, intersections of outlet pipes, hoods, transformers, Y's, dampers, gates, exhausts, and separators; make fan housings; and estimate volume and velocity of air.

To give the student a knowledge of: the effects of temperature on air; air movements and pressure; measurement of air pressure in pipes; static pressure; dynamic pressure; flow of air in branches; anemometers; fans and their housings; methods of gathering data; ventilating codes; modern trade practices; and insurance underwriters' rules.

Jobs—

From given patterns, building for a gravity system:
Air check valves
Air filters
Wind-breaks
Intake stacks
Outlet stacks
From given patterns, building for a mechanical system:
Air check valves
Air filters
Wind-breaks
Intake stacks
Outlet stacks
Gathering data and drafting patterns for preceding
From data gathered for blower systems

designing,[70] drafting, and making:
- Elbows
- Reduction pipes
- Outlet openings
- Transformers
- Dampers
- Gates

Installing pipes and blowers for:
- Heating systems for shops
- Air driers
- Exhausts for removing vapor

From data gathered for forced draft system designing, drafting, and making:
- Elbows
- Pipes
- Reductions
- Gates

Installing draft system for:
- Forges
- Furnaces
- Boilers

Gathering data for:
- Blower pipes
- Exhausts for grinding and polishing wheels

From above data designing, drafting, and making:
- Inlet pipes
- Outlet pipes
- Hoods
- Transformers
- Y joints
- Gates
- Dampers
- Separators

Installing exhaust system for grinding and polishing devices

Designing, drafting, and making for wood working machines in a mill:
- Inlet pipes
- Outlet pipes
- Hoods
- Gates (or dampers, separators, and exhausts)

Installing above parts into a complete clean-out system for wood working machines in a mill

CORNICE WORK

Objectives—

To give the student ability to: develop patterns; lay out, cut, form, assemble, and solder various forms of cornices; fasten cornices; make miters; assemble, solder, and rivet joints and miters; paint properly; measure accurately; make all necessary computations; and observe safety precautions.

To give the student a knowledge of: the effects of climatic conditions on the various kinds of metal; the proper kinds of supports; good joints; building codes; and insurance underwriters' rules.

Jobs—

Assembling and soldering simple cornices

Erecting cornices of various shapes on:
- Wooden supports
- Iron brackets

From given patterns making simple cornices and miters

Drafting simple cornices and cornice miters

Transferring from pattern to metal, cutting, forming, soldering, and fastening into place a gable molding with raked profile on a gable

Drafting pattern for simple gable molding with raked profile on gable end

Making from pattern, putting into place, and soldering a pediment miter on a wash on a building

From given data, drafting a pattern for a pediment miter on a wash

Transferring from pattern, cutting, forming, putting into place, and soldering all joints of a cornice for a building requiring molds of different profiles

From given data, drafting patterns for miters for molds of different profiles

SKYLIGHT WORK

Objectives—

To give the student the ability to: collect data; measure frames and profiles; draft, cut, and form common bars, common bar caps, side bars, banding ridge bars, ridge bar caps, hip bars, hip bar caps, jack bars, and jack bar caps; pitch common bars; join various parts; set frames; and put in glass.

To give the student a knowledge of: condensation; moisture in air; effects of climatic conditions on metals; flashing; kinds of material used; methods of fastening; modern trade practices; city building

[70] Students by this time should have had enough experience in drafting and construction work so that the order of procedure may be changed, putting the drafting first. The nature of the work makes this desirable.

ordinances; building codes; and underwriters' rules.

Jobs—

Making from patterns of a flat skylight:
- Common bars
- Curb bars for back of frame
- Standing curb bars for top of frame
- Caps for various bars

Assembling parts of skylight
Riveting joints
Soldering joints
Putting frame into place
Setting glass
From given data, drafting patterns for:
- Common bar and cap
- Curb bar and cap
- Standing curb bar and cap

From patterns for a curbless skylight, making:
- Top and side bars
- Common bars, common bar clips, common bar caps
- Metal banding

Assembling and joining parts
Placing skylight in opening
Putting glass in frame
Drafting pattern for common bar with clip
Making from patterns for a double pitched skylight
- Common bars
- Ridge bars
- Gable bars
- Bar caps and clips

Assembling parts of double pitched skylight
Putting double pitched skylight into place
Fastening skylight
Making from patterns for a hipped skylight:
- Curb bar
- Ridge bar
- Common bar
- Hip bar
- Jack bar
- Bar caps

Assembling parts of hipped skylight
Fastening skylight into opening
From data gathered from hipped skylights, drafting patterns for:
- Hip bar
- Jack bar

Supplemental Subjects

One of the requirements of the State Board of Education of Indiana is that a teacher of industrial arts shall have not only a specified amount of training in his own line of work, but also that this training be supplemented by the study of other subjects which contribute to his general teaching intelligence.[71] This type of training is needed by the teacher in order that he may meet successfully the problems and situations that arise in his own work and that he may be able to cooperate intelligently with the work of other teachers.

The jobs that were listed in the eighth chapter of the thesis, "The Analysis," which is omitted from this treatise, and the desired technical and auxiliary information given in the same chapter are all helpful to the prospective teacher of sheet-metal work in enabling him to obtain the ability to do. The required supplemental training will foster his ability to be and to apply. The most practical men are the men who can think through concrete situations, who have imagination, and who can dream dreams of organization and of science. The industrial arts teacher needs to discover among his pupils the thinker or the potential thinker and to help him to realize that back of his hand is a brain which he must use.

"Rousseau says, 'The common profession of all men is humanity; and whoever is well educated to discharge the duties of a man cannot be badly prepared to fill up any of those offices that have a relation to him.' "[72] Doctor Turner, research assistant of the State Board of Education of Wisconsin, says, "If we had a real thinker stationed at every occupational post, a real thinker controlling every operation in industry, who can say how fast indus-

[71] *Laws of Indiana Relating to Public Schools* (1927), p. 45.

[72] Jennie McMullin Turner in Federal Board for Vocational Education Bulletin, No. 87, p. 48.

trial progress would go?"[73] The educational work of such firms as the Westinghouse at East Pittsburgh, the New York Edison Company, and the Ford plant all tend to show that enlightened industry finds it worth-while to train employees not merely for better work but also for better living. In view of this fact it would seem especially important that the teacher of shop subjects should have a breadth of training that will enable him to cooperate in meeting the needs of all sorts of pupils with all sorts of backgrounds.

The supplemental subjects required by the State Board of Education of Indiana are: education, English, mathematics, science, social studies, and physical education. Building up the content of the subjects supplemental to the shop work of the student who is preparing to be a sheet-metal teacher is not properly a part of this analysis, hence only a brief statement of the nature and purpose of each is here given.

Education.—This includes a thorough study of the nervous system as it functions in sensation, perception, instinct, feeling, and emotion. Special attention is given to methods of learning, association, memory and habit, to principles and methods relating to selection and organization of subject matter, to the fundamental principles of teaching and survey of important methods and types of teaching, to problems of technique and management, and to the pedagogical treatment of each child as a result of individual differences. This study should give guidance that may be used in a practical way by the future teacher, as well as furnish a measure of orientation toward the school and toward society and its problems.

English.—The aim of the English that is required in the course of the special teacher of industrial arts is to give prospective teachers ability to use correct English and to enable them to think clearly and to express their thoughts in clean-cut sentences. It is desirable that teachers be clear, vigorous, convincing speakers. "A person's ability to receive and give orders, write reports, take part in conferences and executive meetings depends largely upon one's power to use the English language clearly, concisely, and at times forcibly."[74]

Mathematics.—The course designed to meet the needs of students specializing in industrial arts includes algebra, geometry, logarithms, and trigonometry. Special emphasis is placed on numerical trigonometry, although the analytic trigonometry is not neglected.

Science.—The subject matter of this course includes the fundamentals of the subject of physics, and a brief course in electricity and magnetism. These studies form a basis that should enable the student to solve the practical problems of the trade. These problems may be taken up by the teacher of sheet-metal as they present themselves in his work.

Social Studies.—A study is made of the products, markets, and labor problems of the colonial period; economic aspects of the period of the Revolution and Confederation; foreign trade; internal improvements; the rise of the factory system; the public railroads; banking and currency; agricultural products and markets; slavery; the tariff question; economic conditions during the Civil War; and the economic developments and problems of the decade following the Civil War.[75]

Such studies have little relation to the student's ability as a craftsman, but they have considerable bearing on his value as a teacher. It seems especially fitting that the teacher of industrial arts should have the education which will enable him to encourage among his pupils the right views on the social and economic life of our country. In a bulletin issued by the Scovill Manufacturing Company is the following statement which tends to show the need of fostering in our public schools a better understanding of our economic situation: "A study of the history of the development of industry will show that the invention of every labor-saving ma-

[73]Jennie McMullin Turner, *Apprentice Education*, p. 48.

[74]Jennie McMullin Turner, *op. cit.*, p. 52.

[75]These statements of the subject matter required in the supplemental subjects are adapted from those given in the 1930-1931 catalog of the Indiana State Teachers College, *Indiana State Teachers College Bulletion*, Vol. XXIII, No. 6, pp. 126, 170-4, 178, 199, 220, and 228.

chine was opposed by the working people, but that every machine that increased production was a benefit to every one concerned, the working people as well as the mill owners. Such a study will bring out strongly that anything that increases production is for the good of the whole community, and that anything or any group of people that holds up production hurts everyone concerned, themselves as well as the entire community. This will necessitate a study of elementary economics, and the conclusions will emphasize the laws of economics. An understanding of the principles of economics, the relation of production and wages to price, etc., will do much to relieve or prevent industrial unrest and radicalism. But very few men have a clear understanding of our government, of the relation and obligation of the individual citizen and the government to each other."[76]

The Wisconsin State Federation of Labor takes a stand in favor of a study of our present human institutions in the light of their development and of their promise for the future. "We want our children to learn to see the economic, political, and other institutions of our country not as mere established forms but as moving, changing organizations of changing men and women; organizations built up out of struggles for political, economic, religious, intellectual freedom; organizations that must continue to change with changing conditions and needs."[77] Such statements seem to lend emphasis to the belief that the teacher of industrial arts should be especially well prepared to foster good citizenship.

Physical Education.—The purpose of this course is to give the pupil such information and habits as will enable him to maintain at all times his maximum physical efficiency. It is planned primarily to develop certain skills which may be pursued in leisure time, and to promote health habits in so far as exercise is concerned. Especial attention should be given to first aid requirements that may be needed in connection with working with metals and acids.

SUMMARY

In this section the writer has stressed the fact that the teacher of sheet-metal should be trained not only in skill and in those subjects needed as a basis for the performance of the tasks of the sheet-metal worker, but that he should also be trained in those subjects which tend to make him creative and to build for him a general social effectiveness. The supplemental subjects should help him to become a teacher of broad understanding and of clear vision.

[76] *Scovill Bulletin* published by the Scovill Manufacturing Company, September-October, 1921, pp. 32-33.

[77] Jennie McMullin Turner, *op. cit.*, pp. 53-54.

Abstract of The Development Teacher Training in Indiana Prior to 1900

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The purpose of this study was to present a picture of the development of teacher training in Indiana prior to 1900. In presenting this picture definite problems were kept in mind, namely: (1) the major factors influencing the development of teacher training in Indiana; (2) the types of agencies developing to care for the demand for better trained teachers; (3) the kind of training offered by each type of teacher training agency; (4) the difficulties encountered in maintaining a definite teacher training program.

The data used in this study were secured from such primary sources as: catalogs of academies, seminaries, colleges, universities, and normal schools; reports of the superintendents of public instruction; the School Laws of Indiana; the Session Laws and Revised Statutes of the General Assembly of Indiana; *Minutes of the State Board of Education; Indiana School Journal;* newspapers; opinions of the attorney general; court decisions; and reminiscences of older citizens. The principal secondary sources included: histories of Indiana; histories of Indiana counties; histories of teacher training; researches made in institutions of higher education concerning teacher training, teacher licensing, and early teacher training institutions; investigations of teacher training in other states; and general textbooks and references in the field of the history of education.

The historical method was used in this investigation. In all cases, careful historical criticism of sources was exercised so that only such material as seemed to constitute valid evidence was used to form the foundation of this study.

To present this picture it was necessary to show how Indiana and the entire United States had been influenced by European, primarily Prussian, backgrounds, although the idea of teacher training had probably first been born in the United States independently of any knowledge of European institutions. This idea grew into a conviction on the part of the early educators. The revisions of public school systems in numerous states, the publication of educational journals, the work of educational societies, the introduction of the Lancastrian system, certain legislative enactments, and the introduction of normal departments in academies were among the factors which laid the foundation for the first normal schools, located for the most part in Massachusetts, formed the pattern for the other normal schools which were to follow.

National forces exerted an influence in the development of teacher training in Indiana. The Ordinance of 1785 and the Ordinance of 1787 provided for a school system in what was to become the state of Indiana. Accordingly, in the Indiana Constitution of 1816, there appeared the statement that it should be the duty of the

General Assembly "....to provide by law for a general system of education, ascending in regular gradation from township schools to a State University, wherein tuition shall be gratis and equally open to all."

To provide this system of education, there developed the Indiana public school system. Elementary schools were established throughout the settled sections of the state. Academies and seminaries, the latter specifically provided for in the Constitution of 1816 and the County Seminary Law of 1818, were founded to care for the early secondary education. In the field of higher education, there was founded, in 1807, Vincennes University, and, in 1820, Indiana State Seminary. This State Seminary became, in 1828, Indiana College, and, in 1838, Indiana University. Thus Indiana prepared to fulfill her educational duty as announced in the Constitution of 1816.

Flaws, however, began to appear in the school system. The early teachers proved incompetent. Certification practices proved to be most unsatisfactory. Academies and seminaries either failed to materialize or were thought by many to furnish an education unsuited to the Indiana frontier life. Better schools, more adequately trained teachers, more specific certification techniques were demanded by the people. These demands became legal enactments seeking to provide a better school system and, following the enactment of laws, changes were made in the educational system to fulfill the requirements provided for by the laws.

Among the earliest of legal enactments seeking to improve the educational system in Indiana was the Law of 1837 providing that the circuit court should appoint annually three examiners to license candidates for teaching in each county. This law took the sole authority to license teachers away from the township trustee, who had shown himself to be an undesirable examiner, and placed the examination in the hands of a group of men, two of whom must certify to the candidate's fitness and the branches of learning each candidate was qualified to teach. In 1841, and again in 1849, acts of the General Assembly reaffirmed the principal provisions of the Law of 1837 concerned with teacher licensing.

The effects of the Law of 1837 became manifest in the institutions of secondary education throughout the state. In the academies and seminaries courses were introduced to enable the prospective teacher to pass the examinations provided by the county examiners. These courses were, for the most part, of a type known as the review course and were, usually, offered in the spring term of the educational institutions. As examples of such courses, this dissertation presented, among others, a discussion of the normal course introduced in the Delaney Academy in 1843, and the normal department and model school conducted by the Princeton Male and Female Academy in 1848.

Likewise, in the institutions of higher education the effects of the Law of 1837 became evident. For example, Hanover College, in 1840, introduced a course in special instruction in the art of teaching and review courses, while Wabash College, in 1851, established a normal school and offered review courses and lectures on the art of teaching.

The adoption of a new constitution for Indiana in 1852 introduced many changes in the licensing of teachers, changes leading toward a centralization of the power to grant teachers' licenses by placing of such power in the hands of the state. Section 8 of Article VIII of the Constitution of 1852 created the office of state superintendent of public instruction, and the Law of 1852 authorized this newly created officer to personally, or by deputy appointed by him in each county, examine all applicants for license, and, if such were found qualified, to license them as common school teachers for one or two years. In 1853, however, this power of the state superintendent of public instruction to appoint examiners in each county was transferred to the county commissioners, and courses were announced in which a candidate for a teachers' license must pass an examination.

As a result of these legal enactments, courses to provide more adequate preparation for prospective teachers were introduced in various educational agencies.

For example, in 1853, White-Water Academy, and, in 1855, the Bloomington Female College and Academy, introduced courses to prepare prospective teachers. Indiana University, in 1852, opened a normal school containing a model school. Butler University, in 1859, created a department of normal instruction. In the city of Richmond a normal high school was organized to train teachers for the Richmond public schools.

Since bad roads and poor means of transportation made attendance at institutions of higher education impossible for many seeking license to teach, there developed, in answer to the demands of the laws governing licensing, the beginnings of the county institute movement, the first meetings of which organization were held in the fall of 1852.

The year 1834 marked the organization of one minor agency which was to serve as the "watchdog" for the teachers of the state, an agency ever searching for favorable legislation, ever demanding and encouraging higher professional and academic standards, —the Indiana State Teachers' Association.

The decade between 1860 and 1870 witnessed many changes in the laws regulating the licensing of teachers and saw introduced into the licensing field many regulations of the state board of education. In 1860 the state superintendent was authorized to license teachers at his pleasure, but, in 1861, this power was abolished and the licensing of teachers placed in the hands of a county examiner appointed by the county commissioners for a term of three years. The Law of 1865 reaffirmed the Law of 1861 and made provisions for determining the form of the teachers' examinations and the duration of time for which a license should be valid.

To aid in the fulfillment of the provisions of the Law of 1865, the state board of education: (1) declared that applicants for a teacher's license must display proficiency in the theory and practice of teaching, (2) determined the academic fields to be covered in the teachers' examinations, (3) announced the time and place of teachers' examinations, and (4) appointed a committee from the state board of education to conduct teachers' examinations at the state normal institutes. In 1867 the state board of education authorized the president of the board to conduct teachers' examinations at the state normal institutes and, in 1868, appointed the state superintendent of public instruction as chairman of the committee on examination of teachers. In 1869, the members of the committee on teachers' examinations of the state board were authorized to conduct examinations in their own districts and to submit the examination papers to the state superintendent of public instruction for marking.

With laws passed by the General Assembly and regulations promulgated by the state board of education establishing a machinery for the conducting of teachers' examinations and for the granting of teachers' licenses, and with the announcement of the courses over which teachers' examinations were to be conducted, there came a development of teacher training programs in the various educational agencies throughout the state. Representative of the movement in the seminaries and academies was the course in pedagogics introduced into the curriculum of the Spiceland Academy in 1864. In other educational institutions, also, professionalized courses were introduced. Union Christian College, located at Merom, introduced, in 1868, a course of lectures on teaching. In this same year, Indiana University reorganized its normal department and established a professorship of English literature and theory and practice of teaching. DePauw University, in 1867, established a normal course, professionalized only in that the course consisted of a review of subject matter intended to aid the prospective teacher in passing the teachers' examinations.

Among the minor educational agencies the laws and state board regulations found a ready response. Normal departments in high schools to train teachers for the respective cities were organized at Anderson in 1860, at Indianapolis in 1867, and at Peru in 1869. The year 1862 marked the beginning of the private normal institute movement, more commonly called

the summer normal school movement. On March 6, 1865, an act was passed legalizing the county institute movement. By this same act funds were provided to maintain and develop the county institute. In 1865, the township institute movement had its beginning. Likewise, in this same year the state normal institute movement was begun, four such institutes being held in 1867, and three in 1868. These institute movements exhibit evidence of the demand by teachers in all sections of the state for more professionalized instruction to enable them to meet the increased licensing requirements.

The decade from 1870 to 1880 marked the centralization of control over licensing in the hands of the state board of education. In 1871, the state board of education passed a resolution which declared that it, i. e., the state board, would prepare twelve sets of teachers' examination papers, one set for each month, and that these were to be sent to, and used by, the county examiner. Each set of questions was to include a section on "Theory and Practice of Teaching." In this same year, 1871, an act of the General Assembly provided that a board of school commissioners was to assume the duties of the county commissioners in all cities of 30,000 or more inhabitants. In 1873, the "County Superintendency Law" was enacted, declaring that the county superintendent was to assume the duties of the county examiner. Furthering the centralization of control of licensing, the state board of education, in 1874, made each member of the board responsible for teachers' examination questions on a particular subject.

While this centralization movement was in progress, developments in teacher training were in progress in the educational institutions throughout the state. In 1870 after years of discussion of the merits of such a school, the Indiana State Normal School was opened at Terre Haute. This State Normal School offered professional courses and professionalized subject matter courses leading to all types of licenses. In the summer of 1870 the first summer school at an institution of higher education was offered at the State Normal School, the second school to offer such work being Central Normal College at Danville, in 1879. In 1870, also, a normal school was established at Moore's Hill College. Spiceland Academy, representative of the movement in the academies and seminaries, introduced in 1874 a course in professional instruction in which the science and art of pedagogy was presented. The year 1878 marked the beginning of a movement destined to develop rapidly in the next two decades, i. e., the movement termed in this study the private normal school. Central Normal College is representative of this rise of private normal schools. In 1878 it established a teachers' department.

The decade 1870 to 1880 likewise witnessed developments in the minor educational agencies. In 1870, county institutes were held in forty-six counties with 4,033 persons attending. In 1873, an act of the General Assembly legalized the township institute. By 1875 the state superintendent of public instruction recognized the influence of the private normal institute movement to be of such importance as to include an account of it in his *Report* to the General Assembly. In 1876, it was estimated that 3,000 teachers were in attendance at these private normal institutes. In 1875, a high school normal department was organized at Logansport. The year 1878 marked the formation of an organization to care for the problems peculiar to a certain section of the state, —the Southern Indiana Teachers' Association. Five years later, i. e., in 1883, a similar association, the Northern Indiana Teachers' Association, was organized to care for regional problems in the northern part of Indiana.

The decade from 1880 to 1890 was characterized by the widespread establishment of normal departments and departments of pedagogy. At the opening of the decade, in 1880, the state board of education passed a regulation declaring that each set of questions for teachers' examinations should include questions on "methods of teaching the subject." When coupled with the state board regulation of 1871 requiring teachers' examinations on "Theory and Practice of Teaching," it became necessary for those institutions

of higher education desiring to train teachers to introduce the study of professional courses into their curriculums. That this was done will be evidenced by a rapid scanning of the development of professional courses in such educational institutions.

In the seminary and academy field, professional courses were widely introduced. As examples of this movement, Hartsville Academy, in 1885, introduced a normal course with instruction in improved methods of teaching. Fairmount Academy, in 1884, offered a course in pedagogy and psychology. In 1886, Union Christian College at Merom established a normal course which soon included the study of pedagogy and methods of teaching. At Plainfield, Central Academy, in 1888, offered a normal course including the study of pedagogy.

The private normal schools were quick to provide courses to fulfill the requirements for teachers' licenses as announced by the state board regulations. At Angola, Tri-State Normal College, in 1884, maintained a one-year teachers' course, and also established a department of pedagogy. In the same year, the Richmond Normal School announced a three-year course offered in the normal department and declared that administrators, as well as classroom teachers, were prepared in this department. In 1885, the Southern Indiana Normal College, at Mitchell, introduced a teachers' department in which a teachers' training class was organized every term, and special emphasis placed on training in the philosophy of methods. In addition to this professional course, philosophy of methods, the Southern Indiana Normal College also offered the following professional courses: outline of psychology, hints on training the faculties, methods of school management, and methods of instruction. Central Normal College, in 1889, announced that the teacher training program had been so organized as to include the entire second year of the four-year college course offered by the institution.

The state supported educational institutions were likewise quick to realize the necessity of professionalized courses to prepare prospective teachers for passing license examinations. In 1880, Indiana University, although the normal department had been closed in 1873, offered special lectures in pedagogics. In 1885, Indiana University once more offered a regular course in pedagogics which included a course in history of education and lectures and practical drills in the work of teaching. In 1886, a department of pedagogics was created in Indiana University, in which department the following professional courses were offered: educational psychology, school economics, history of education, teaching as an art, school supervision, philosophy of education, foreign school systems, American school systems, school legislation, and high school teaching.

Vincennes University, however, did not respond so rapidly to the growing necessity for professional courses. In 1884, Vincennes organized a review course for teachers. In 1885, a teachers' class was introduced. The work of this class, however, consisted primarily of reviews of subject matter taught in the common schools. A course in pedagogy was a part of the work of this teachers' class, but it consisted of lectures given three times each week upon some phase of the topic, "pedagogy." It was not until the next decade that Vincennes University introduced purely professional courses into its curriculum.

Since the work of the Indiana State Normal School was, by the very nature of the school, definitely professionalized, no discussion of its work is necessary here.

In the denominational colleges throughout the state of Indiana came a rapid response to the demand for professional instruction. This is evidenced by the provisions made by these institutions for the admission of, and the offering of courses for, those individuals desirous of becoming teachers. Developments in Earlham College, DePauw University, and Franklin College are representative of the movement in institutions of this type. Earlham College, in 1880, introduced a normal class during the spring term. The work in this normal class included courses in: school organization, discipline, class instruction, history of education, and the workings of

the common school system. Three years later, in 1883, work in pedagogics was introduced, the principal offering of which was a course in the theory and methods of teaching. DePauw University, in 1883, organized a special school known as the "School of Pedagogy." This school offered the following professional courses: art of education, psychology applied to teaching, Indiana school laws, methods of teaching, and theory and practice of teaching. In 1884, this special school was made the normal school and ranked as one of the regular divisions of the university. In 1886, this normal school offered the following professional courses: study of the school, the recitation, educational psychology, observation and practice, and philosophy and history of education. In 1889, the DePauw Normal School offered the following professional courses other than those offered in 1886: logical method in United States history, grammar, arithmetic, and geography; general method logical and psychological; organization and primary method in United States history, grammar, arithmetic, and geography; science of the recitation; method in rhetoric; logical method in general history and physiology; method in algebra; method in primary reading; method in advanced reading; primary method in natural science; method in literary analysis for high school; philosophy of education; practice in the training school; history of education; method in geometry; and the science of school supervision.

Franklin College, the third institution used to exemplify the trend of professional course development in denominational schools, opened, in 1885, a department of pedagogy. A course offering a study in methods and discipline was the focus of this department. In 1888, Franklin College opened a "Teachers' Course" in the spring term offering courses in pedagogics and reviews of the common branches. From the courses offered in these three representative institutions, the trend toward professional courses is demonstrated.

While the licensing laws and state board regulations were affecting curricular changes in educational institutions, the minor educational agencies were also adapting themselves to the new requirements. In 1880 there came a pronounced change in the type of instruction offered in the county institutes. From reviews of subject matter taught in the common schools, the county institute programs became lectures delivered on professional subjects. In the next year, 1881, the state board of education began the preparation of programs for all county institutes, thus securing uniformity of county institute offerings. In 1885, this idea of uniformity of programs was extended to the township institute, wherein programs prepared by the state superintendent of public instruction were followed from that date on. In 1883, professional instruction was still further advanced through the organization of the Indiana Teachers' Reading Circle movement. In 1885, work in the science of teaching completed as a part of the reading circle course was accepted in lieu of the county superintendent's examination in this field.

Thus, in the period from 1880 to 1890, the regulations relative to teacher licensing made by the state board of education and the legal enactments passed upon the same subject had caused to be introduced into the educational program of institutions preparing teachers for the schools of Indiana definite professional courses.

The last decade discussed by this study, i. e., 1890-1900, witnessed few changes in licensing laws and state board of education regulations but did evidence a further development of the inclusion of professional courses in educational institutions preparing teachers for the public schools and did witness the early beginnings of uniformity in the name and content of professional courses.

Legal enactments and state board regulations between 1890 and 1900 declared that the county superintendent must possess a teacher's license, that all applicants for a teacher's license must pass an examination upon the nature of alcoholic drinks and narcotics, and, in 1899, that a distinction would be made between elementary and high school licenses. Licensing enactments and regulations and regulations of the previous decade, how-

ever, were still causing changes in the curricular offerings of educational institutions. Professional courses were becoming a part of the curriculums in all institutions preparing teachers.

In the field of the academies, seminaries, and small colleges, for example, St. Joseph's College, located at Collegeville, introduced, in 1891, a curriculum for teachers which included a course in pedagogy. Taylor University, at Upland, offered, in 1894, a "Normal Course" which included work in such professional courses as mental science and the history and philosophy of education. Manchester College, in 1895, offered a one-year course in pedagogical studies, which included such professional courses as history of education, educational psychology, and methods of teaching. Union Christian College, at Merom, offered, in 1896, professional courses in school management, lectures on theory and practice, school law, and lectures on psychology, ethics, child study, and methods of organization. In 1898, Union Christian College added to its professional offerings courses in the history of education, psychology, and the philosophy of teaching. Fairmount Academy, in 1898, added history of education to its professional course offerings, while Central Academy, in 1900, introduced courses in psychology and pedagogy.

The private normal schools also witnessed a marked development of professional courses. In 1890, the Marion Normal College and Business Institute conducted a normal school department offering courses leading to all types of licenses. By 1896, this department offered the following professional courses: history of education, psychology, philosophy of education, special methods, and practice teaching. In 1892, the Northern Indiana Normal School and Business Institute at Valparaiso introduced a teachers' department in which methods in primary teaching and theory and practice of teaching were among the courses offered. In 1892, Central Normal College at Danville introduced professional courses cataloged as: history of education, methodology, science of education, and teacher training. In 1895, Tri-State Normal College, at Angola, offered a one-year "Teachers' Course" and a two-year "Pedagogical Course." Curricular offerings included: psychology applied to teaching, methods, management, and history of the science and art of education. In 1899, this pedagogical course became known as the professional department.

In the state supported institutions of higher education the introduction of professional courses continued. Vincennes University, in 1896, created a department of pedagogy and listed, among the professional courses offered, methods in arithmetic, grammar, and geography. Indiana University, by 1898, had included among its courses those entitled elementary pedagogy, modern school systems and problems, and a pedagogical seminary. The State Normal School work was, as stated before, so definitely professionalized that no detailed summary will be made here.

In the other colleges in Indiana, the demands of the licensing laws and regulations were, between 1890 and 1900, still being fulfilled by the creation, or further development, of departments offering professionalized instruction. Oakland City College introduced a normal course in 1892. Hanover College, in 1893, introduced a course in the theory and practice of teaching. Earlham College, in 1895, opened a spring term for teachers, and, by 1899, was offering such professional courses as history of education, school systems, general pedagogy, general psychology, physiological psychology, and educational psychology. Butler University, in 1897, created a department of philosophy and pedagogy offering the following professional courses: history of education, educational psychology, public school systems, educational methods, experimental psychology, and psychology of childhood. Wabash College, in 1899, offered a spring course for teachers, while in the same year, a department of pedagogy was created in Earlham College.

Among the minor educational agencies, the most outstanding development of the decade from 1890 to 1900 was the establishment of summer sessions in the institutions of higher education. This movement had a beginning in 1870 when a summer session was conducted in the In-

diana State Normal School, and again in 1879, when the Central Normal College conducted a summer session. It did not flourish, however, until the decade under discussion. By 1890, the demand for more professional training, the realization on the part of school administrators of the possibility of an increased utilization of the school plant, and improvements in transportation making attendance in summer months possible, all led to the establishment of the summer session. In 1890, Indiana University introduced the movement. In 1892, summer sessions were conducted in Wabash Colllege, Earlham College, and DePauw University. In 1895, Franklin College joined the movement by conducting a summer session.

Other minor educational agencies also evidenced pronounced growth during the decade. In 1898, county institutes were held in every county in the state with a total attendance of 15,870 individuals. In the reading circle movement, 14,397 persons were enrolled in 1899, and, in 1900, the township institute movement recorded 6,829 township institutes held.

With this summary the picture of teacher training in Indiana prior to 1900 is brought to an end. From a period in which the local government controlled all requirements for teaching, Indiana had developed a centralized control of teacher licensing. This centralization of authority led to the promulgation of a teacher training program which necessitated the introduction of professional courses into the curriculums of teacher training agencies throughout the state.